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Niagara River Mussel Biomonitoring Program, 2000

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Report prepared by:
Lisa A. Richman
Water Monitoring Section
Environmental Monitoring and Reporting Branch

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FOREWORD

The data generated by the 2000 Niagara River Biomonitoring Survey augment other federal and provincial Niagara River Toxics Management Plan programs by providing information on contaminants in the river between Fort Erie and Niagara-on-the-Lake. The Niagara River mussel biomonitoring survey, conducted by the Ontario Ministry of Environment, has been ongoing since 1980 (Kauss 1987; Kauss and Angelow 1988; Anderson *et al.* 1991; Richman 1992 - 1999).

Information provided by this study is part of an overall program to assess long-term trends in contaminant loadings from selected U.S. and Canadian sources along the Niagara River.

ACKNOWLEDGEMENTS

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SUMMARY

Since 1980 the Ontario Ministry of Environment (MOE) has been committed to both routine and specialized biomonitoring of contaminants in the Niagara River using caged mussels (*Elliptio complanata*) as part of Ontario's commitment to the Niagara River Toxic Management Plan. Mussels were deployed on the American as well as the Canadian side of the river. These studies have provided information on suspected contaminant sources and source areas in the river between Fort Erie and Niagara-on-the-Lake (Kauss 1987; Kauss and Angelow 1988; Anderson *et al.* 1991; Richman 1992; Richman 1993; Richman 1994; Richman 1997, Richman 1999).

In 2000, there were two complementary studies;(a) the routine deployment of caged mussels at 30 stations on the Canadian and American sides of the river for 21 days of exposure, and (b) the long term deployment of mussels for up to four months at a station in Two Mile Creek. Mussels were retrieved after the designated period of deployment and the tissues were analysed for organochlorine pesticides, total polychlorinated biphenyls (PCBs), chlorinated benzenes, and polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF).

Twenty-one day Deployment - Summary of Findings.

Mussels placed at three of the five stations on the Canadian side of the river accumulated trace concentrations of p,p'-DDE (metabolite of the pesticide DDT). Trace concentrations were also detected at 20 stations on the American side of the river. The presence of p,p'-DDE in the mussels was likely due to the historic use of DDT in the Lake Erie and Niagara River watersheds. Juvenile fish data collected by MOE and New York State Department of Environmental Conservations (NYSDEC) were consistent with the mussel data (MOE unpublished data; Preddice et al. 2002).

The detection of organochlorine pesticides (chlordane, α-BHC, β-BHC and γ-BHC), in mussels deployed along the Niagara River was sporadic. These parameters were only detected in mussels on the American side of the river and concentrations were similar to those seen in previous surveys. The highest concentrations of all BHC isomers were found in mussels deployed in Gill Creek upstream of the creek mouth. The long term data base suggested that BHC was associated with this creek and possible sources should be investigated.

Trace concentrations of total PCBs were present in mussels deployed at all stations on the American side of the river and in mussels deployed in Lyons Creek and at Niagara-on-the-

Lake (NOTL) on the Canadian side. MOE is presently investigating the source of PCBs to Lyons Creek and possible remedial actions to deal with contaminated sediment. Generally, concentrations of total PCBs among all stations on the American side of the river were similar (with only one exception), making it difficult to identify possible point or non-point sources along the Tonawanda Channel and in the lower river. Although remedial activities are expected to reduce the loadings of PCBs to the Niagara River, the data suggested (including the NOTL data), that PCB contamination is pervasive and PCBs will continue to be bioavailable in the future, similar to DDT and its metabolites.

The highest concentration of total PCBs (mean 280 ng/g SD 52.9 ng/g) for the three week survey were present in mussels deployed at station 43 which is about 15 m downstream of an inactive sewer associated with the Occidental Chemical Corporation Buffalo Avenue plant. PCB concentrations in mussels deployed at all remaining sewers associated with the Occidental plant tended to fall within the range detected in mussels deployed at other stations upstream and downstream along the Niagara River. The anomalously elevated concentrations at this location provide strong evidence of increased exposure to PCBs, particularly when viewed in conjunction with data from 1993/95. This site should be investigated further by the responsible parties to determine whether this is attributable to a locally controllable source of PCBs.

Total PCB concentrations in mussels deployed at the mouth of Gill Creek have been consistently low in recent surveys when compared with concentrations detected in mussels prior to the remediation of the site. Since the site was remediated, mean concentrations have ranged from 81 ng/g (SD 19 ng/g) in 1993 to 50 ng/g, SD 12 ng/g in 2000.

Another site in Gill Creek, north of Highway 384 (upstream of the area previously remediated for PCBs), typically had high concentrations of PCBs in mussels in previous surveys suggesting additional source(s) of PCBs to this area (Richman 1993; Richman 1997). Remedial action in the area to remove contaminated sediment was completed in 1998. PCBs were still detected in mussels deployed at this site in 2000, however, concentrations were lower than in previous years and similar to levels detected at most sites in the Niagara River (mean 80 ng/g).

Chlorinated benzenes were not detected in any mussels deployed on the Canadian side of the river with the exception of trace concentrations of pentachlorobenzene in one mussel (3 ng/g) at Fort Erie and at Lyons Creek.

The most frequently detected chlorinated compounds on the American side of the river in mussel tissue were hexachlorobenzene, hexachlorobutadiene, and pentachlorobenzene. Mussels deployed at the mouth of Bloody Run Creek and at the Occidental Sewer 003 had the highest concentrations of HCB, pentachlorobenzene and 1,2,3,4-tetrachlorobenzene when compared with other stations. The data for HCB and pentachlorobenzene at both sites were consistent with results from the early 1980's and throughout the 1990s.

Concentrations of chlorinated benzenes in mussels deployed at the 102nd Street Landfill and at the Pettit Flume inlet cove were low in 2000 relative to previous years of sampling prior to site remediation. However, high concentrations of dioxins and furans were detected in deployed mussels and sediment collected from the cove in 1997 and again in 2000 suggesting that the flume is still an active source of dioxins and furans despite remedial efforts. The sediment TEQ was 30,250 pg/g which indicates extremely contaminated sediment. The Canadian Environmental Quality Guideline "probable effect level" has been set at 21.5 pg/g (CCME 2001).

Sediment collected from Two Mile Creek and from the station in Gill Creek upstream of the creek mouth were contaminated with dioxins and furans. The TEQs for the sediment samples were 81 and 100 pg/g respectively. The sediment collected from Gill Creek is of particular interest since the area was remediated in 1998. This data suggests a recent source of dioxins and furans.

Dioxin and furan concentrations in sediment from the Niagara River shoreline at the Bloody Run Creek site were considerably lower in 2000 than previous surveys. However, since the shoreline has not been remediated the data likely represent the spatial variability in contamination due to the 1994 rock slide rather than an improvement or decrease in sediment contamination. Concentrations of dioxins and furans in mussels and sediment indicate that this site is contaminated with these parameters (TEQ in sediment 3,732 pg/g) and that they are bioavailable.

Long Term Deployment of Caged Mussels - Summary of Findings.

Mussels deployed for up to 105 days showed rapid initial uptake of PCBs within 48 hours and then a slow increase and levelling off of tissue concentrations with time for 42 days (range: 60 - 100 ng/g). Between 42 and 63 days of deployment (from August 22 to September 12, 2000), exposure to PCBs may have changed since tissue concentrations increased to a mean of 160 ng/g (SD 34.6; range 140 - 200 ng/g). Mussels retrieved on day 84 and 105 had similar PCB concentrations as those exposed for 63 days possibly indicating that a new steady state had been reached. PCB loadings may have increased due to a large rainstorm (48.6 mm), either through the flushing of storm sewers located upstream in the creek or through disturbances to the contaminated sediment.

A similar pattern of uptake was observed in mussels which were deployed at staggered intervals confirming that the 21 day survey was sufficient to assess bioaccumulation of PCBs in *Elliptio* provided there were no changes in exposure. However, the environment is in a constant state of flux due to external forces such as storm events or fluctuations in contaminant loadings from local industries. The data suggested that the mussel tissue concentrations will respond to this dynamic environment. The disadvantage of short term monitoring programs using introduced organisms is that significant contaminant inputs can be missed if they occur outside the designated period of biomonitoring.

Summary of organochlorine pesticides, PCBs, industrial compounds and chlorinated benzene contaminants in caged mussel tissue from the 21 day exposure to the Niagara River. Station locations in Fig. 1 and Appendix A & B.

Canadian Sites	***Contaminant*** ($_{(t)}$. Trace concentrations, interpret with caution)
Fort Erie at Robertson Street	pp'-DDE$_{(t)}$, pentachlorobenzene$_{(t)}$
Boyers Creek (mouth)	
Chippawa Channel	
Niagara-on-the-Lake	PCBs$_{(t)}$, pp'-DDE$_{(t)}$
Lyons Creek	PCBs$_{(t)}$, pp'-DDE$_{(t)}$, pentachlorobenzene$_{(t)}$
US Sites	***Contaminant*** ($_{(t)}$. Trace concentrations, interpret with caution)
Buffalo River	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
Tonawanda Channel	pp'-DDE$_{(t)}$, PCBs$_{(t)}$ pentachlorobenzene$_{(t)}$
Tonawanda Channel (upstream of Two Mile Ck)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$, pentachlorobenzene$_{(t)}$
Two Mile Creek (mouth)	pp'-DDE$_{(t)}$,PCBs$_{(t)}$
Pettit Flume (upstream)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
Pettit Flume (site B)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$, HCB$_{(t)}$, pentachlorobenzene, 1,2,3,4-tetrachlorobenzene$_{(t)}$, 1,2,3,5-tetrachlorobenzene$_{(t)}$, 2,3,6-trichlorotoluene$_{(t)}$.
Pettit Flume (downstream)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
Gratwick/Riverside Park (upstream)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
Gratwick/Riverside Park	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
102nd Street Landfill (upstream)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
102nd Street Landfill	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
Upstream (Occidental) Sewer A	pp'-DDE$_{(t)}$, PCBs$_{(t)}$
(Occidental) Sewer A	PCBs$_{(t)}$, HCB$_{(t)}$
(Occidental) Sewer B	PCBs$_{(t)}$, HCB$_{(t)}$
(Occidental) - between Sewer B and Sewer C	PCBs$_{(t)}$, HCB$_{(t)}$
(Occidental) Sewer C	PCBs$_{(t)}$, HCB
(Occidental) - (between Sewer C and Sewer 003)	b-BHC$_{(t)}$, g-chlordane$_{(t)}$, PCBs, pp'-DDE$_{(t)}$, hexachlorobutadiene$_{(t)}$, HCB, octachlorostyrene$_{(t)}$, pentachlorobenzene$_{(t)}$, 1,2,3,4-tetrachlorobenzene$_{(t)}$, 1,2,4,5-tetrachlorobenzene$_{(t)}$

Occidental Sewer 003	g-chlordane$_{(t)}$, pp'-DDE, PCBs$_{(t)}$, hexachlorobutadiene, HCB, pentachlorobenzene, 1,2,3,4-tetrachlorobenzene, 1,2,4,5-tetrachlorobenzene$_{(t)}$, 1,2,3,5-tetrachlorobenzene$_{(t)}$, 1,3,5-trichlorobenzene$_{(t)}$, 2,3,6-trichlorotoluene$_{(t)}$, 2,4,5-trichlorotoluene$_{(t)}$
Occidental - Storm Sewer	pp'-DDE$_{(t)}$, PCBs$_{(t)}$, hexachlorobutadiene$_{(t)}$, HCB$_{(t)}$ pentachlorobenzene$_{(t)}$, 2,3,6-trichlorotoluene$_{(t)}$, 2,4,5-trichlorotoluene$_{(t)}$, 1,2,3,4-tetrachlorobenzene$_{(t)}$
Gill Creek (upstream)	a-BHC, b-BHC$_{(t)}$, g-BHC$_{(t)}$, PCBs$_{(t)}$, pp'-DDE$_{(t)}$,
Gill Creek (mouth)	a-BHC$_{(t)}$, pp'-DDE$_{(t)}$, PCBs$_{(t)}$, hexachlorobutadiene, 1,3,5-trichlorobenzene$_{(t)}$
Bloody Run Creek (upstream)	pp'-DDE$_{(t)}$, pentachlorobenzene$_{(t)}$, 2,3,6-trichlorotoluene$_{(t)}$,
Bloody Run Creek	b-BHC$_{(t)}$, pp'-DDE$_{(t)}$, PCBs$_{(t)}$, hexachlorobutadiene, HCB, pentachlorobenzene, 2,3,6-trichlorotoluene, 2,4,5-trichlorotoluene$_{(t)}$, 1,2,3,4-tetrachlorobenzene$_{(t)}$, 1,2,3,5-tetrachlorobenzene$_{(t)}$, 1,2,4,5-tetrachlorobenzene$_{(t)}$, 1,3,5-trichlorobenzene$_{(t)}$, dichlorobenzly chloride$_{(t)}$
Bloody Run Creek (downstream)	pp'-DDE$_{(t)}$, PCBs$_{(t)}$, HCB$_{(t)}$ pentachlorobenzene$_{(t)}$, 2,3,6-trichlorotoluene$_{(t)}$

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INTRODUCTION

The Niagara River was historically contaminated and continues to be contaminated by the discharge of persistent bioaccumulative and toxic chemicals from outfalls and hazardous waste landfills (Elder *et al.* 1981; Kuntz and Warry 1983; Jaffe and Hites 1984; NRTC 1984; Gradient Corp./Geotrans Inc. 1988; Monenco 1991; Raven 1991).These contaminants impact the integrity of the aquatic ecosystem including fish and wildlife habitat throughout the Niagara River and Lake Ontario. They include chemicals such as mirex, PCBs (polychlorinated biphenyls), organochlorine pesticides such as γ- BHC (lindane) and chlordane, chlorinated benzenes, chlorinated phenols, polycyclic aromatic hydrocarbons (PAH), and polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) (Interagency Task Force on Hazardous Waste 1979; Elder *et al.* 1981; Jaffe and Hites 1984; NRTC 1984; US EPA and NYSDEC 2002, Niagara River Data Interpretation Group 1996). Recent efforts by the Canadian and U.S. governments to remediate hazardous waste sites and control effluent discharges from point and non-point sources, however, have resulted in improvements in the water quality of the Niagara River (Niagara River Secretariat 2002).

Since 1980, the Ontario Ministry of Environment (MOE) has undertaken routine and specialized biomonitoring of contaminants in the Niagara River using caged mussels (*Elliptio complanata*) in addition to other long term monitoring programs (spottail shiner contaminant monitoring and the sport fish contaminant monitoring program), as part of Ontario's commitment to the Niagara River Toxics Management Plan. This plan was part of a binational agreement (first signed in 1987), to improve the environmental quality of the Niagara River. The cooperative assistance of the New York State Department of Environmental Conservation (NYSDEC) has enabled the MOE to deploy mussels on the American as well as the Canadian side of the river. The mussel biomonitoring program has provided information on suspected contaminant sources and source areas and the effectiveness of site remediation in reducing contaminants in the river between Fort Erie and Niagara-on-the-Lake (Kauss 1987; Kauss and Angelow 1988; Anderson *et al.* 1991; Richman 1992-1999).

Biomonitors are an effective means of detecting bioaccumulative contaminants in the water when ambient concentrations are too low to be measured directly using conventional water sampling and analytical methods. The principle behind the mussel biomonitoring program is to take organisms from an uncontaminated site and place them in an environment that is known or suspected of being contaminated with persistent bioaccumulative substances. The biomonitors are left for a specified time to accumulate contaminants and are then analysed to determine the contaminant concentrations in their tissue. By strategically locating the organisms upstream and downstream from a source, the presence or absence of the contaminants in the water body can be determined. The detection of the contaminants in the mussels indicates that these contaminants are bioavailable in the aquatic environment. The absence of a contaminant in the mussel tissue is less definitive. It may suggest that the contaminant is not present or it is not bioavailable in the surrounding environment. However, because of the site specific nature of this biomonitor it may also mean that the mussels were not placed near enough to the source to adequately detect the presence of the contaminants.

The freshwater mussel, *Elliptio complanata*, is a filter feeder feeding on plankton and organic detritus and will, therefore, accumulate contaminants directly from the water column and from particulate matter (Pennak 1978). This method of feeding renders the mussel a good biomonitor since contaminants tend to partition between the dissolved phase and the solid phase where they become associated with sediment or suspended particulates through adsorptive processes. Mussels are abundant and easily collected and transported. They are sedentary organisms and responsive to their environment. Mussels can integrate short term fluctuations in contaminant levels and, accordingly, tissue concentrations reflect short term contaminant pulses which may not be detected by routine water quality monitoring (Muncaster *et al.* 1989; Metcalfe and Charlton 1990; Kauss and Hamdy 1991; Lobel *et al.* 1991). Conversely, because the sampling design is limited to a particular deployment period, results only reflect the exposure during that period. The results obtained at any one sampling event represent the current contamination integrated by that specific organism and cannot be extrapolated to yearly loadings from sources. Likewise, significant contaminant inputs could be missed if they occur outside the designated period of biomonitoring.

Objectives

The general objective of the mussel biomonitoring program is to monitor the distribution of contaminants in the Niagara River and identify areas of concern for point and non-point source investigations.

More specific objectives of this survey were to investigate:

- *how tissue contaminant concentrations of caged mussels deployed in the Niagara River for 21 days varied spatially between the stations*
- *the qualitative temporal patterns associated with the presence/absence of contaminants (i.e. are specific contaminants consistently detected at specific locations over time?).*
- *the effectiveness of remedial actions at point and non-point sources*
- *the variability in contaminant uptake patterns in caged mussels deployed over a long term (4 month) exposure.*

This report presents the results of the 2000 mussel biomonitoring survey.

METHODS

Field Sampling and Station Locations

Caged Mussels

In 2000, there were two studies initiated by the MOE; the routine deployment of caged mussels at near shore stations on the Canadian and American sides of the river for 21 days of exposure, and the long term deployment of caged mussels for up to four months at Two Mile Creek. The long term deployment survey was a follow up to similar surveys in 1995 and 1997 (Richman 1997; Richman 1999).

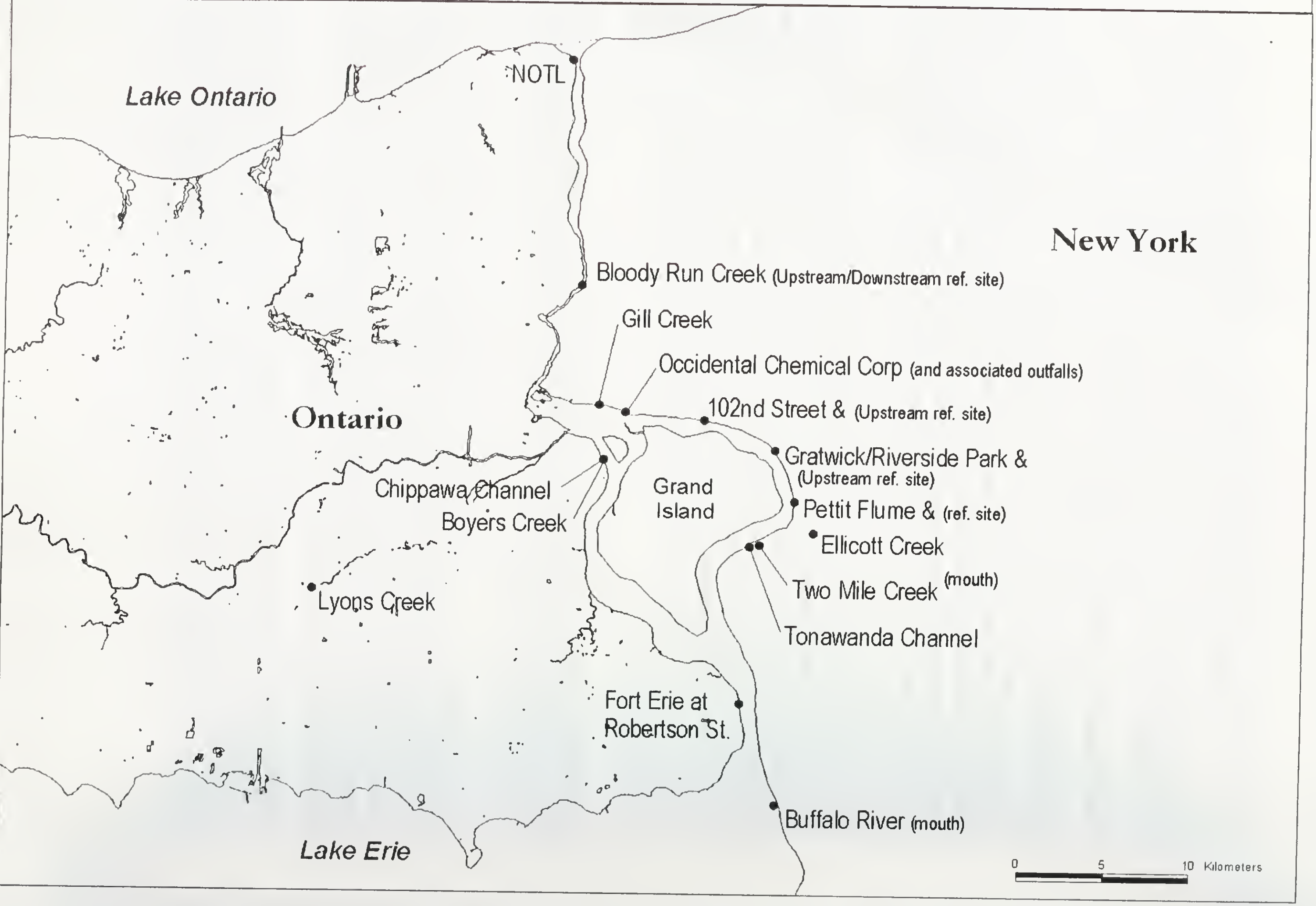
The mussels used for the study originated from Balsam Lake (a relatively uncontaminated lake located in Victoria County, Ontario). Only mussels between 6.5 and 7.2 cm were collected to reduce variability due to tissue weight and mussel age. The mussels were collected by divers and placed in buckets lined with clean bioassay (food-grade) polyethylene bags partially filled with lake water for transportation. The bags were sealed with air trapped inside and rapid temperature fluctuations were avoided. Three of these mussels were randomly selected and submitted for tissue analysis to determine initial concentrations of contaminants. These mussels are referred to as the Balsam Lake control mussels in this report.

Mussels were placed in the Niagara River at 30 sampling stations during the week of July 12, 2000 and retrieved after three weeks of exposure during the week of August 1, 2000 (Figure 1; Appendix A & B for latitude/longitude). Retrieval of caged mussels for the three week survey was successful at all stations.

Sampling stations were located at the mouth of tributaries, in the Tonawanda Channel, Chippawa Channel and near known industries and hazardous waste sites. The cages were usually placed within two to three metres from shore because the study was designed to investigate the impact of shore based sources on water quality rather than ambient river conditions. Appendix A provides a detailed diagram of the outfalls monitored in front of the Occidental Chemical Corporation Buffalo Avenue property.

At each station at least six mussels were placed in 30 x 45 cm envelope-shaped cages constructed of 1.25 cm galvanized mesh poultry netting. A nylon rope was attached to the cages and then anchored to the river bottom with a cement block. Cages were also anchored to the bottom using pegs or rocks and sometimes attached to a shoreline structure. The mussels were immediately shucked after retrieval, excess water was drained

Figure 1: Station Location for Niagara River Mussel Biomonitoring Survey, 2000


Lake Ontario
NOTL
New York
Bloody Run Creek (Upstream/Downstream ref. site)
Gill Creek
Occidental Chemical Corp (and associated outfalls)
Ontario
102nd Street & (Upstream ref. site)
Gratwick/Riverside Park & (Upstream ref. site)
Chippawa Channel
Boyers Creek
Grand Island
Pettit Flume & (ref. site)
Ellicott Creek
Two Mile Creek (mouth)
Lyons Creek
Tonawanda Channel
Fort Erie at Robertson St.
Buffalo River (mouth)
Lake Erie
0
5
10 Kilometers

and the soft tissues were weighed (Appendix C), individually wrapped in hexane-rinsed aluminum foil, and placed in plastic bags. Three individual mussels were analysed for contaminants at each station (percent lipid, organochlorine pesticides (OC), total PCBs and chlorinated benzenes (CB), Table 1). The remaining mussels were frozen and archived.

At nine of these sites an additional four mussels were composited into one sample for dioxin/furan and dioxin-like PCB analysis and surficial sediment grab samples were collected as discussed below.

In addition to the routine 21 day deployment, a sufficient number of mussels were deployed in cages at Two Mile Creek for long term exposure experiments. Three randomly selected mussels from this batch were retrieved on each of days 1, 2, 3, 7, 14, 21, 42, 63, 84 and 105 days (15 weeks). On day 21, 16 additional mussels were deployed in separate cages and three mussels from this batch were randomly selected on each of days 42, 63, 84 and 105 noted above (i.e. exposure times of these mussels was for 21, 42, 63 and 84 days respectively). Similarly, on day 42 above, 12 additional mussels were deployed in additional cages and three mussels from this batch were randomly selected on each of days 63, 84 and 105 (i.e. exposure for those mussels was for only 21, 42, and 63 days respectively). Mussels were analysed for total PCBs, OCs and CBs and percent lipid. One surficial sediment sample was collected on day 105 and analyzed for PCBs, total organic carbon (TOC) and particle size.

Sediment

Surficial sediment samples (top 3 cm) were collected from nine stations for analysis of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, particle size and TOC using a stainless steel spatula and placed in sample jars. Samples were kept on ice in the field, and refrigerated at 4°C in the dark until analysis. The general sample composition (e.g. sand, silt etc.), sediment colour, any unusual features were recorded.

Analytical Methods

All laboratory analytical procedures for contaminants in mussels and sediment and for particle size analysis in sediment followed the methodology outlined in the Handbook of Analytical Methods for Environmental Samples (OMOE 1983). Procedural updates for biomaterial and sediment analysis were provided in OMOEE (1995; 1997; 2000) and OMOE (1999; 2000a and b). All results for mussels were reported on a wet weight basis. Results for sediment were reported on a dry weight basis.

TABLE 1: Mussel tissue was submitted for the following analyses.

All samples were sumbitted for the following analyses:		Samples from eight stations
		were submitted for:
PCBs (total)	1,3,5-trichlorobenzene	Polychlorinated dibenzo-p-dioxins
Heptachlor	1,2,4-trichlorobenzene	Polychlorinated dibenzofurans
Aldrin	1,2,3-trichlorobenzene	
Photomirex	1,2,4,5-tetrachlorobenzene	
Mirex	1,2,3,4-tetrachlorobenzene	
α–BHC	1,2,3,5-tetrachlorobenzene	
β–BHC	Pentachlorobenzene	
γ–BHC	Hexachlorobenzene	
α–chlordane	2,4,5-trichlorotoluene	
γ–chlordane	2,3,6-trichlorotoluene	
pp-DDE	2,6-dichlorobenzyl chloride	
op-DDT		
pp-DDD		
pp-DDT		
Octachlorostyrene		
Toxaphene		
Hexachloroethane		
Hexachlorobutadiene		

Data Analysis

The range in contaminant concentrations in mussels was provided for replicate samples for each parameter at each station in tables summarized within the report. Means and standard deviations were provided if all three mussels had quantifiable concentrations of a parameter (i.e. >w). Concentrations described as "trace" (t) represents the smallest amount of an analyte that can be quantified. "w" values represent the smallest amount of an analyte that can be detected by the procedure used. Both are based on the precision of the method based on replicate measurements for the same analyte. "w" is set at 2/3 of the standard deviation while "t" is set at 5 or 10 times "w" for organic parameters. "t" is generally equal to or higher than the method detection limit. All "raw data" are presented in Appendix B. Values at trace concentrations are noted by a "t" in the Appendix.

RESULTS AND DISCUSSION

Organochlorine pesticides, total PCBs and chlorinated benzenes were not detected in the Balsam Lake control mussels. Dioxin-like PCB which are analysed using a lower detection limit than total PCBs were present at low concentrations (pg/g). A comparison of the Balsam Lake mussel data for dioxin-like PCBs with samples collected from sites in the Niagara River is provided in Table 5.

Organochlorine Pesticides

Mussels placed at three of the five stations on the Canadian side of the river accumulated trace concentrations of p,p'-DDE (metabolite of the pesticide DDT). Trace concentrations were also observed at almost all stations on the American side of the river (Table 2). The frequency of detecting DDE at various stations and concentrations present in the mussel tissue (with only two exceptions, concentrations were all less than 7 ng/g), were consistent with previous years of monitoring (Kauss and Angelow 1988; Anderson *et al.* 1991; Richman 1992-1999). The presence of p,p'-DDE in the mussels was likely due to the historic use of DDT in the Lake Erie and Niagara River watersheds. Since DDT and its metabolites are persistent organic compounds, they continue to remain bioavailable in the environment. Juvenile fish data collected by MOE and the 1997 young-of-year (YOY) fish data collected by NYSDEC showed frequent detection of DDE in fish tissue although concentrations were below the wildlife criterion of 200 ppb for DDT (MOE unpublished data; Preddice *et al.* 2002).

The detection of hexachlorocyclohexanes (α-BHC, β-BHC and γ-BHC), in mussels deployed along the Niagara River has always been sporadic. However, although tissue concentrations have varied between survey years among the three isomers, hexachlorocyclohexanes have been consistently detected in mussels deployed in Gill

TABLE 2: Range in concentrations (ng/g wet weight) of organochlorine pesticides and PCBs in mussels introduced to the Niagara River for three weeks, 2000. If all replicate samples were above the detection limit the mean and standard deviation was also provided.

Sampling Station	Station	α-BHC	mean	β-BHC	mean	γ-BHC	mean	α-Chlordane	γ-Chlordane	mean	Total PCBs	mean	pp'-DDE	mean
Canadian Sites														
Fort Erie at Robertson St	(5-2)-203	.		.		.			.		.		(.)-4	
Boyers Creek	(5-15)-5	.		.		.			.		.		.	
Lyons Creek	(5-15)-20	.		.		.			.		60 - 100	80	(.)-3	
												(20)		
Chippawa Channel	(5-2)-51	.		.		.			.		.		.	
NOTL	(11-2)-9	.		.		.			.		40	40	( )-3	
												(0)		
US Sites														
Buffalo River (Downstream)	(5-2)-220	.		.		.			.		40 - 60	53	2 - 4	3
												(11.5)		1 0
Tonawanda Channel	(5-2)-3	.		.		.			.		40 - 60	47	2 - 4	3
												(11 5)		1.0
Tonawanda Channel (upstream of Two	(5-2)-92	.		.		.			.		40 - 60	47	2 - 3	2
Mile Creek)												(11.5)		0.6
Two Mile Creek (mouth)	(5-2)-197	.		.		.			.		80 - 100	93	( )-2	
												(11.5)		
Ellicott Creek (Columbus Mckinnon)	(5-15)-32	.		.		.		(.)-4	.		40 - 80	60	5-7	6
												(20)		1.1
Pettit Flume (upstream)	(5-2)-185	.		.		.			.		40 - 80	60	2 - 4	3
												(20)		1 2
Pettit Flume (site B)	(5-2)-186	.		.		.			.		80 - 80	87	(.)-2	
												(11.5)		
Pettit Flume (downstream)	(5-2)-187	.		.		.			.		40 - 60	53	2 - 4	3
												(11 5)		1 2
Gratwick/Riverside Park (upstream)	(5-2)-31	.		.		.			.		80 - 100	90	(.)-2	
												(12)		
Gratwick/Riverside Park	(5-2)-199	.		.		.			.		60 - 100	80	(.)-3	
												(20)		
102nd Street (upstream)	(5-2)-93	.		.		.			.		60 - 80	67	3 - 3	3
												(11 5)		0
102nd Street	(5-2)-22	.		.		.			.		40 - 80	60	2 - 3	2.7
												(20)		0.6
Upstream Sewer A	(5-2)-47	.		.		.			.		40 - 100	67	(.)-52	
												(30.5)		
Sewer A	(5-2)-46	.		.		.			.		40 - 60	47	.	
												(11.5)		
Sewer B	(5-2)-94	.		.		.			.		40 - 60	47	.	
												(11.5)		
Between Sewer B and Sewer C	(5-2)-45	.		.		.			.		40 - 80	60	.	
												(20)		
Sewer C	(5-2)-44	.		.		.			.		40 - 60	53	.	
												(11 5)		
Between Sewer C and Sewer 003	(5-2)-43	.		(.)-8		.			(.)-8		240 - 340	280	5 - 6	6
												(52 9)		(0.6)
Occidental Sewer 003	(5-2)-42	.		.		.			( )-4		40 - 60	53	(.)-21	
												(11 5)		
Storm Sewer - S&N	(5-2)-40	.		.		.			.		60 - 100	73	(.)-5	
												(23.1)		
Gill Creek (upstream)	(5-15)-22	18 - 28	20	5 - 7	8	2 - 3	2		.		80 - 80	80	(.)-6	
			(5.1)		(1 1)		(0 6)					(0)		
Gill Creek	(5-2)-37	2 - 2	2	.		.			.		40 - 60	53	( )-2	
			(0)									(11 5)		
Bloody Run Creek (upstream)	(11-2)-18	.				.			.		.		(.)-2	
Bloody Run Creek (mouth)	(11-2)-17	.		5 - 8	8	.			.		60 - 80	67	(.)-3	
					(0 6)							(11.5)		
Bloody Run Creek (Downstream)	(11-2)-25	.		.		.			.		(.)-40		(.)-2	
Balsam Lake Control Mussels	(18-1)-1													

" " compound was not detected

Aldrin, Heptachlor, Toxaphene, Photomirex, γ-BHC, γ-chlordane, p'p-DDD and o'p-DDT were not detected in any samples analysed

NOTL=Niagara -on-the-Lake

Creek since 1987 (either at the mouth of the creek or the station in the creek upstream of Highway 384) (Anderson *et al.* 1991; Richman 1992-1999). The highest concentrations in mussels detected in 2000 were for α-BHC (range: 16 to 26 ng/g), at the Gill Creek upstream station, while only trace concentrations of β-BHC and γ-BHC were detected at the same location. Only trace concentrations of α-BHC were detected at the mouth of the creek. In 1997 YOY fish collected from the upstream creek station exceeded the NYSDEC non-carcinogenic wildlife criterion of 100 ppb (Preddice *et al.* 2002) and were by far the highest concentrations detected in fish compared with the other Niagara River sites. Concentrations in caged mussels have never been as high as the fish data, but the consistent detection of -BHC in this creek when combined with the YOY data suggest that potential sources to the creek should be investigated.

Trace concentrations of β-BHC were also detected in mussels at one sewer associated with the Occidental Chemical Corporation (Buffalo Avenue plant), and at the mouth of Bloody Run Creek. Trace concentrations of γ-chlordane, were detected in mussels at two of the Occidental sewers. Concentrations of these parameters in mussel tissue were similar to those detected in previous surveys.

The absence of these compounds in mussels deployed at the 102nd Street waste site in both 1997 and 2000 is noteworthy. Detectable concentrations of α-BHC, β-BHC and γ-BHC have routinely been present in mussels deployed at this site prior to the remedial activities. Site remediation (construction of a slurry wall around the waste site) and the removal of contaminated sediment from the river reduced the presence and bioavailability of these contaminants in the river.

Polychlorinated Biphenyls (PCBs)

Trace concentrations of total PCBs were detected in mussels deployed in Lyons Creek and at Niagara-on-the-Lake (NOTL) on the Canadian side of the river. MOE is presently investigating the source of PCBs to Lyons Creek and possible remedial actions for contaminated sediment. This was the first year that PCBs were detected in mussels at the NOTL site since routine monitoring began in 1983. Future surveys will include this site to assess the presence of a local previously unidentified source, however, since concentrations were low they likely reflect the presence of PCBs in the lower Niagara River.

Trace concentrations of total PCBs were present in mussels deployed at all stations on the American side of the river (Table 2). Generally concentrations among all stations were similar (with the exception of station 43), making it difficult to identify possible point or non-point sources along the Tonawanda Channel and in the lower Niagara River. These results were consistent with the data from 1997. The ongoing remediation of historical hazardous waste sites, contaminated sediment and sewer outfalls are expected to reduce the release of PCBs from these non-point sources which contributes to an overall reduction of PCB loadings to the Niagara River and Lake Ontario. However, the data suggest that PCB exposure is pervasive in the Niagara River and that PCBs will likely be bioavailable in the future, similar to the continued bioavailability of DDT and its metabolites.

The highest concentration of total PCBs for the three week survey were present in mussels deployed about 15 m downstream of a sewer associated with the Occidental chemical plant (station 43 -Appendix A). Concentrations at that site range from 240 to 340 ng/g. These data were consistent with the congener specific PCB data where the sum of all congeners detected ranged from 290 to 320 ng/g (Table 3). Sixty-one congeners were analysed. Tetra and pentachlorinated biphenyls were present at the highest concentrations and represented over 90% of the total PCB concentration. The highest concentrations of two dioxin-like PCBs (congener 105 and 118) were also detected in the mussels deployed at this site. The sewer (station 44) upstream of this site is supposed to be inactive and does not discharge process water. The mean PCB concentration in mussels at that site was 53 ng/g (SD 11.5 ng/g). The high PCB concentration at station 43 may be due to surface runoff or contaminants leaching through shoreline rock and rubble from contaminated soil. While PCB concentrations in mussels deployed at all the other sites associated with the Occidental plant tend to fall within the range detected in mussels deployed upstream and downstream along the Niagara River, high concentrations have been previously detected in mussels deployed at this specific station. In 1997 only trace concentrations of total PCBs were detected there, but concentrations ranged as high as 322 ng/g and 260 ng/g in 1993 and 1995 respectively. The anomalously elevated concentrations at this location provide strong evidence of increased exposure to PCBs, particularly when viewed in conjunction with 1993/95 data. This site should be investigated further by the responsible parties to determine whether this is attributable to a locally controllable source of PCBs.

Typically, high concentrations of PCBs have been detected in mussels deployed in Two Mile Creek when compared with other sites in the survey. This creek has been identified by NYSDEC as being contaminated with PCBs (Niagara River Secretariat 2002). In 1987 concentrations ranged from below the detection limit to 239 ng/g. In 1991 and 1993 the mean concentrations were 108 ng/g (SD 32 ng/g) and 129 ng/g (SD 15.7 ng/g) respectively, while in 1997 the tissue concentrations ranged as high as 160 ng/g after 28 days of deployment. In 2000, PCB concentrations (range: 80 to 100 ng/g) were higher than concentrations observed in mussels deployed in the Tonawanda Channel upstream of the creek (range: 40 to 60 ng/g), but similar to concentrations detected in mussels deployed at other sites downstream in the Niagara River.

Total PCB concentrations in mussels deployed at the mouth of Gill Creek have been consistently low in recent surveys when compared with concentrations detected in mussels prior to the remediation of the site. A major clean up of PCB contaminated sediment upstream of the mouth of Gill Creek was completed in 1992. Gill Creek was historically a known PCB "hot spot" (Interagency Task Force on Hazardous Waste 1979; Raven

Table 3: Concentrations of PCBs (ng/g wet wt.) in caged mussels deployed for 21 days, Niagara River, 2000

Homologue groups	Congeners	Two Mile Creek Stn. 197		Two Mile Creek Stn. 197		Gratwick Riverside Park Stn. 31		Gill Creek (upstream) Stn. 22		Gill Creek (upstream) Stn. 22		Downstream Sewer C Stn. 43		Downstream Sewer C Stn. 43		Downstream Sewer C Stn. 43		Sewer 003 Stn. 42	
	PCB001	0		0		0		0		0		0		0		0		0	
	PCB003	0		0		0		0		0		0		0		0		0	
	PCB004	0		0		0		0		0		0		0		0		0	
	PCB008	0		0		0		0		0		0		0		0		0	
	PCB010	0		0		0		0		0		0		0		0		0	
Tri	PCB015	0		0		0		0		0		0		0		0		0	
	PCB018	0		0		0		0		0		0		0		0		0	
	PCB019	0		0		0		0		0		0		0		0		0	
	PCB022	0		0		0		0		0		0		0		0		0	
	PCB028	0		0		0		0		0		9		13		17		0	
	PCB033	0		0		0		0		0		0		0		0		0	
	PCB037	0		0		0		0		2	<t	0		0		7	<t	0	
	PCB044	0		1.6		0.3	<t	3.1		3.8		36		38		24		4.7	
	PCB049	0		0		0		0		0		35		35		42		0.9	<t
	PCB052	2.4		3.9		1.4		7.3		8.2		48		49		57		5.7	
Tetra	PCB054	0		0		0		0.4	<t	0.4	<t	0		0		0		0	
	PCB070	0		0		1.8		1.2		2		37		33		41		0.5	<t
	PCB074	0		0		0.7	<t	8.9		2.7		20		15		23		0	
	PCB077	0		0		0		0		0		0		0		0		0	
	PCB081	0		0		0		0		0		0		0		0		0	
	PCB087	0		0		0		0		0		0		0		0		0	
	PCB095	5.3		7.6		3.7		5.6		7		60		58		72		3.7	
	PCB099	0		0		0		0		0		11		8.9		7.5		0	
	PCB101	1.2		2		0		0		1		12		12		17		0	
	PCB104	0		0		0		0		0		0		0		0		0	
	PCB105	0		0		0		0		0		2.5		4		0		0	
Penta	PCB110	0.6	<t	3.4		0		2.4		3.1		16		17		0.6	<t	0	
	PCB114	0		0		0		0		0		0		0		0		0	
	PCB118	0		0		0		0		0.6	<t	9.1		7.9		11		0	
	PCB119	0		0		0		0		0		0		0		0		0	
	PCB123	0		0		0		0		0		0		0		0		0	
	PCB126	0		0		0		0		0		0		0		0		0	

<t: measurable trace amount

Homologue groups	Congeners	Two Mile Creek Stn. 197		Two Mile Creek Stn. 197		Gratwick Riverside Park Stn. 31		Gill Creek (upstream) Stn. 22		Gill Creek (upstream) Stn. 22		Downstream Sewer C Stn. 43		Downstream Sewer C Stn. 43		Downstream Sewer C Stn. 43		Sewer 003 Stn. 42	
	PCB128	0		0		0		0		0		0		0		0		0	
	PCB138	1.6	<t	2		0		0		0.4	<t	0		0		0		0	
	PCB149	0		0		0		0		0		0		0		0		0	
	PCB151	0		0		0		0		0		0		0		0		0	
	PCB153	0		0		0		0		0		0		0		0		0	
	PCB155	0		0		0		0		0		0		0		0		0	
	PCB156	0		0		0		0		0		0		0		0		0	
Hexa	PCB157	0		0		0		0		0		0		0		0		0	
	PCB158	0		0		0		0		0		0		0		0		0	
	PCB167	0		0		0		0		0		0		0		0		0	
	PCB168	0		0		0		0		0		0		0		0		0	
	PCB169	0		0		0		0		0		0		0		0		0	
	PCB170	0		0		0		0		0		0		0		0		0	
	PCB171	0		0		0		0		0		0		0		0		0	
	PCB177	0		0		0		0		0		0		0		0		0	
	PCB178	0		0		0		0		0		0		0		0		0	
	PCB180	0		0		0		0		0		0		0		0		0	
	PCB183	0		0		0		0		0		0		0		0		0	
Hepta	PCB187	0		0		0		0		0		0		0		0		0	
	PCB188	0		0		0		0		0		0		0		0		0	
	PCB189	0		0		0		0		0		0		0		0		0	
	PCB191	0		0		0		0		0		0		0		0		0	
	PCB194	0		0		0		0		0		0		0		0		0	
	PCB199	0		0		0		0		0		0		0		0		0	
Octa	PCB201	0		0		0		0		0		0		0		0		0	
	PCB202	0		0		0		0		0		0		0		0		0	
	PCB205	0		0		0		0		0		0		0		0		0	
Nano	PCB206	0		0		0		0		0		0		0		0		0	
	PCB208	0		0		0		0		0		0		0		0		0	
Deca	PCBDEC	0		0		0		0		0		0		0		0		0	
	PCB (Total)	12	<t	21	<t	8	<t	29	<t	31	<t	300		290		320		17	<t

<t: measurable trace amount

1991), and a significant source of PCBs to the Niagara River and subsequently Lake Ontario. Prior to remediation mean concentrations in mussels deployed at the creek mouth were as high as 935 ng/g (SD 163 ng/g) in 1987 and 2,623 ng/g (SD 745 ng/g) in 1991 (Figure 2). Since the site was remediated, mean concentrations have ranged from 81 ng/g (SD 19 ng/g) in 1993 to 50 ng/g, SD 12 ng/g in 2000.

Another site in Gill Creek, north of Highway 384 (upstream of the area previously remediated for PCBs), typically had high concentrations of PCBs in mussels in previous surveys suggesting additional source(s) of PCBs to this area (Richman 1993; Richman 1997). Contamination of this site was confirmed by NYSDEC and YOY fish had high tissue concentrations of PCBs in 1997 (Preddice *et al.* 2002). Remedial action in the area to remove contaminated sediment was completed in 1998. PCBs were still detected in mussels deployed at this site in 2000, however, concentrations were similar to levels detected at most sites in the Niagara River (mean 80 ng/g). Prior to site remediation the mean concentration in mussels in 1993 was 157 ng/g (SD 27.7 ng/g) and in 1995 was 200 ng/g (SD 138.5 ng/g).

Congener specific analysis was performed on all mussels deployed for 21 days. However, in addition to the mussels deployed at station 43, individual congeners were only detected in a few samples; two mussels deployed at Two Mile Creek, one mussel at Cayuga Creek, two mussels at Gill Creek (upstream station) and one mussel deployed at sewer 003. With the exception of station 43, the sum of the detected congeners were lower than the concentrations reported for total PCB (Table 2 & 3). Tetra and pentachlorinated biphenyls were the dominant homologue groups present representing 80 to 90% of the total PCB congener concentrations reported. The limited data set for congener specific analysis was likely due to the submission of insufficient biomass for the available detection limits. Future studies will modify the project design to accommodate this analysis at selected stations.

Chlorinated Benzenes and Industrial Compounds

Chlorinated benzenes were not detected in any mussels deployed on the Canadian side of the river with the exception of trace concentrations of pentachlorobenzene in one mussel (3 ng/g) at Fort Erie and at Lyons Creek.

The most frequently detected chlorinated compounds on the American side of the river in mussel tissue were HCB, hexachlorobutadiene (HCBD), and pentachlorobenzene (Table 4). Trichlorobenzene concentrations were low and only detected at a few stations. Octachlorostyrene was present at only one station at trace concentrations (sewer associated with the Occidental Chemical plant), and dichlorobenzyl chloride was only present at Bloody Run Creek.

Mussels deployed at the mouth of Bloody Run Creek and at the Occidental Sewer 003 had the highest concentrations of HCB, pentachlorobenzene and 1,2,3,4-tetrachlorobenzene

Figure 2: Caged Mussel Tissue Concentrations (mean+/-SD; n=3)
Niagara River, 1983-2000

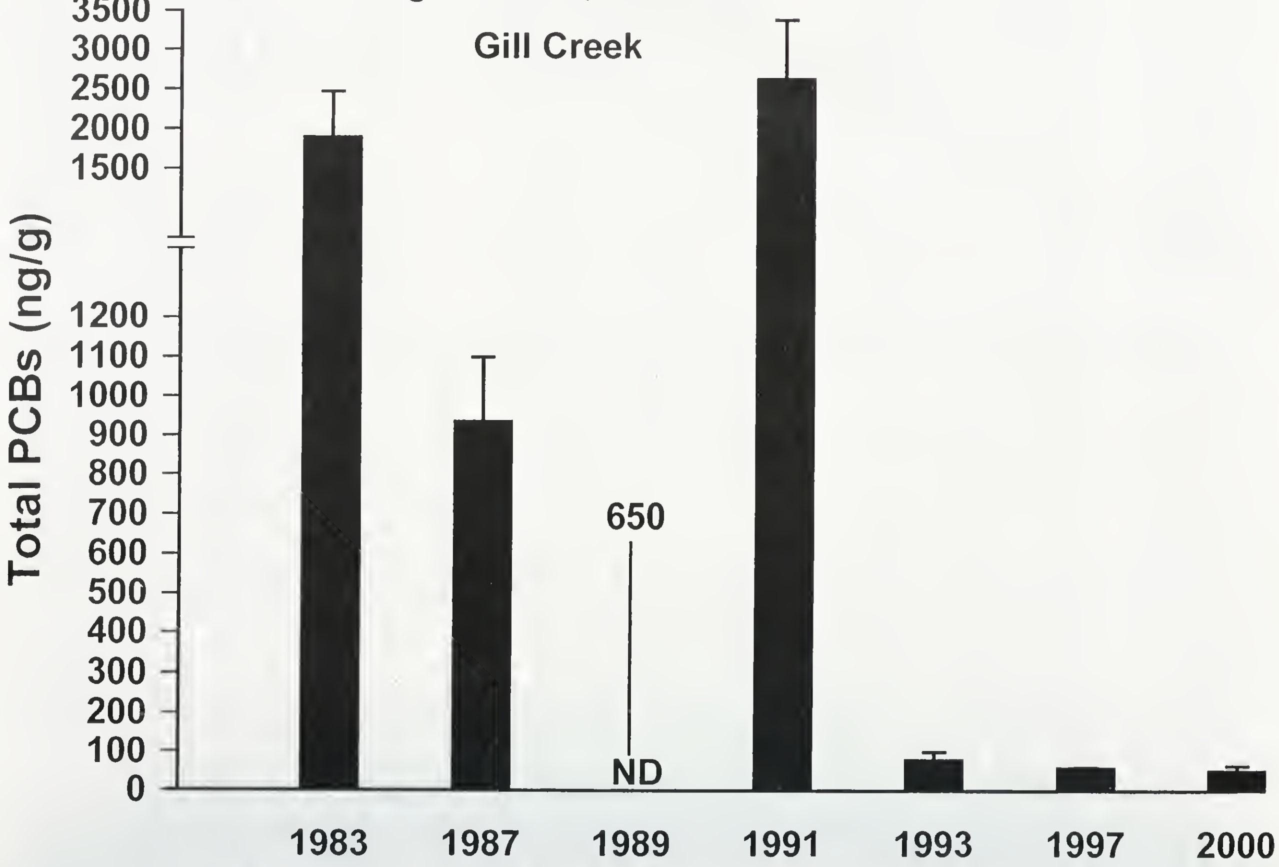


TABLE 4: Range in concentrations (ng/g wet weight) of chlorinated benzenes and chlorinated industrial compounds in mussels introduced to the Niagara River for three weeks, 2000. If all replicate samples were above the detection limit the mean and standard deviation was also provided.

Sampling Station	Station number	Hexa-chlorobutadiene	mean	Hexe-chlorobenzene	mean	Dichloroben-zyl chloride	mean	Octa-chlorostyrene	meen	Penta-chlorobenzene	mean	2,3,6-Trichlorotoluene	mean	2,4,5-Trichlorotoluene	mean
Canadian Sites															
Fort Erie at Robertson St.	(5-2)-203									( )-3					
Boyers Creek	(5-15)-5														
Lyons Creek	(5-15)-20									( )-3					
Chippawa Channel	(5-2)-51														
NOTL	(11-2)-9														
US Sites															
Buffalo River	(5-2)-220														
Tonawanda Channel	(5-2)-3									( )-2					
Tonawanda Channel (upstream of Two Mile Creek)	(5-2)-92									(.)-3					
Two Mile Creek (mouth)	(5-2)-197														
Ellicott Creek (Columbus Mckinnon)	(5-15)-32														
Pettit Flume (upstream)	(5-2)-185														
Pettit Flume (site B)	(5-2)-186	( ) - 2								4 - 14	10 (5 1)	( )-5			
Pettit Flume (downstream)	(5-2)-187														
Gratwick/Riverside Park (upstream)	(5-2)-31														
Gratwick/Riverside Park	(5-2)-199														
102nd Street (upstream)	(5-2)-93														
102nd Street	(5-2)-22														
Upstream Sewer A	(5-2)-47														
Sewer A	(5-2)-46			( ) - 5											
Sewer B	(5-2)-94			( )-2											
Between Sewer B and Sewer C	(5-2)-45			( )-2											
Sewer C	(5-2)-44			(.)-2											
Between Sewer C and Sewer 003	(5-2)-43	4 - 6	5 (1 1)	5-13	8 (4 5)			(.)-5		4 - 18	9 (7 8)				
Occidental Sewer 003	(5-2)-42	42-52	46 (5 3)	(.)-24						20-27	23 (3 6)	( )-10		( )-8	
Storm Sewer - S&N	(5-2)-40	4 - 6	5 (1 1)	5 - 9	7 (2 1)					3 - 5	4 1 2	( )-2		( )-2	
Gill Creek (upstream)	(5-15)-22														
Gill Creek	(5-2)-37	17 - 21	19 (2 1)												
Bloody Run Creek (upstream)	(11-2)-18									( )-3		( )-2			
Bloody Run Creek (mouth)	(11-2)-17	8 - 10	9 (1 0)	13 -20	17 (3 8)	2 - 4	3 (1 0)			24 - 28	27 (2 3)	10 - 12	11 (1 0)	6 - 9	7 (1.5)
Bloody Run Creek (downstream)	(11-2)-25			3 - 8	6 (2 5)					3 - 5	4 (1 2)	5 - 6	6 (0 6)		
Balsam Lake Control Mussels	(18-1)-1														

" " compound was not detected

NOTL=Niagara -on-the-Lake

1,2,3 trichlorobenzene, 1,2,4,trichlorobenzene and hexachloroethane were not detected in any samples analysed

Table 4 continued:

Sampling Station	Station number	1,2,3,4-Tetrachlorobenzene	mean	1,2,3,5-Tetrachlorobenzene	mean	1,2,4,5-Tetrachlorobenzene	mean	1,3,5-Trichlorobenzene	mean
Canadian Sites									
Fort Erie at Robertson St.	(5-2)-203	.		.		.		.	
Boyers Creek	(5-15)-5	.		.		.		.	
Lyons Creek	(5-15)-20	.		.		.		.	
Chippawa Channel	(5-2)-51	.		.		.		.	
NOTL	(11-2)-9	.		.		.		.	
US Sites									
Buffalo River	(5-2)-220	.		.		.		.	
Tonawanda Channel	(5-2)-3	.		.		.		.	
Tonawanda Channel (upstream of Two Mile Creek)	(5-2)-92	.		.		.		.	
Two Mile Creek (mouth)	(5-2)-197	.		.		.		.	
Ellicott Creek (Columbus Mckinnon)	(5-15)-32	.		.		.		.	
Pettit Flume (upstream)	(5-2)-185	.		.		.		.	
Pettit Flume (site B)	(5-2)-186	(.)-6		(.)-3		.		.	
Pettit Flume (downstream)	(5-2)-187	.		.		.		.	
Gratwick/Riverside Park (upstream)	(5-2)-31	.		.		.		.	
Gratwick/Riverside Park	(5-2)-199	.		.		.		.	
102nd Street (upstream)	(5-2)-93	.		.		.		.	
102nd Street	(5-2)-22	.		.		.		.	
Upstream Sewer A	(5-2)-47	.		.		.		.	
Sewer A	(5-2)-46	.		.		.		.	
Sewer B	(5-2)-94	.		.		.		.	
Between Sewer B and Sewer C	(5-2)-45	.		.		.		.	
Sewer C	(5-2)-44	.		.		.		.	
Between Sewer C and Sewer 003	(5-2)-43	2 - 8	4	.		(.)-3		.	
			(3.2)						
Occidental Sewer 003	(5-2)-42	11 - 14	12	(.)-4		(.)-3		(.)-4	
			(1.5)						
Storm Sewer - S&N	(5-2)-40	2 - 4	3	.		.		.	
			(1.0)						
Gill Creek (upstream)	(5-15)-22	.		.		.		.	
Gill Creek	(5-2)-37	.		.		.		(.)-4	
Bloody Run Creek (upstream)	(11-2)-18	.		.		.		.	
Bloody Run Creek (mouth)	(11-2)-17	7 - 8	7	7 - 7	7	3 - 4	3.3	(.)-4	
			(0.6)		(0)		(0.6)		
Bloody Run Creek (downstream)	(11-2)-25	.		.		.		.	
Balsam Lake Control Mussels	(18-1)-1								

when compared with other stations in the survey. The data for HCB and pentachlorobenzene at both sites were consistent with results from mussel surveys in the early 1980s and throughout the 1990s indicating that these areas are sources of these contaminants (Figure 3 & 4). Concentrations of 1,2,3,4-tetrachlorobenzene in mussels deployed at Bloody Run Creek were also consistent with previous surveys back to 1987. Although tetrachlorobenzene was present in mussels at detectable concentrations at the 003 site, concentrations were lower in 1997 and 2000 than in surveys since 1987 (Anderson *et al.* 1991; Richman 1992-1999). However, variability in the data within any one survey has been high.

The highest concentrations of HCBD were present in mussels deployed at Occidental sewer 003 (mean 46 ng/g SD 5.3) and Gill Creek (mean 19 ng/g SD 2.1 ng/g). HCBD has always been associated with these sites in previous surveys, although at times the variability in tissue concentrations at a site has been high. Concentrations in deployed mussels at Gill Creek have ranged from as low as 9 ng/g (SD 1 ng/g) in 1993 to 147 ng/g (SD 23.1 ng/g) in 1997 (Figure 5). HCBD was stored in waste sites which were known to leech contaminants into Gill Creek and was present in Occidental's effluent (NRTC 1984).

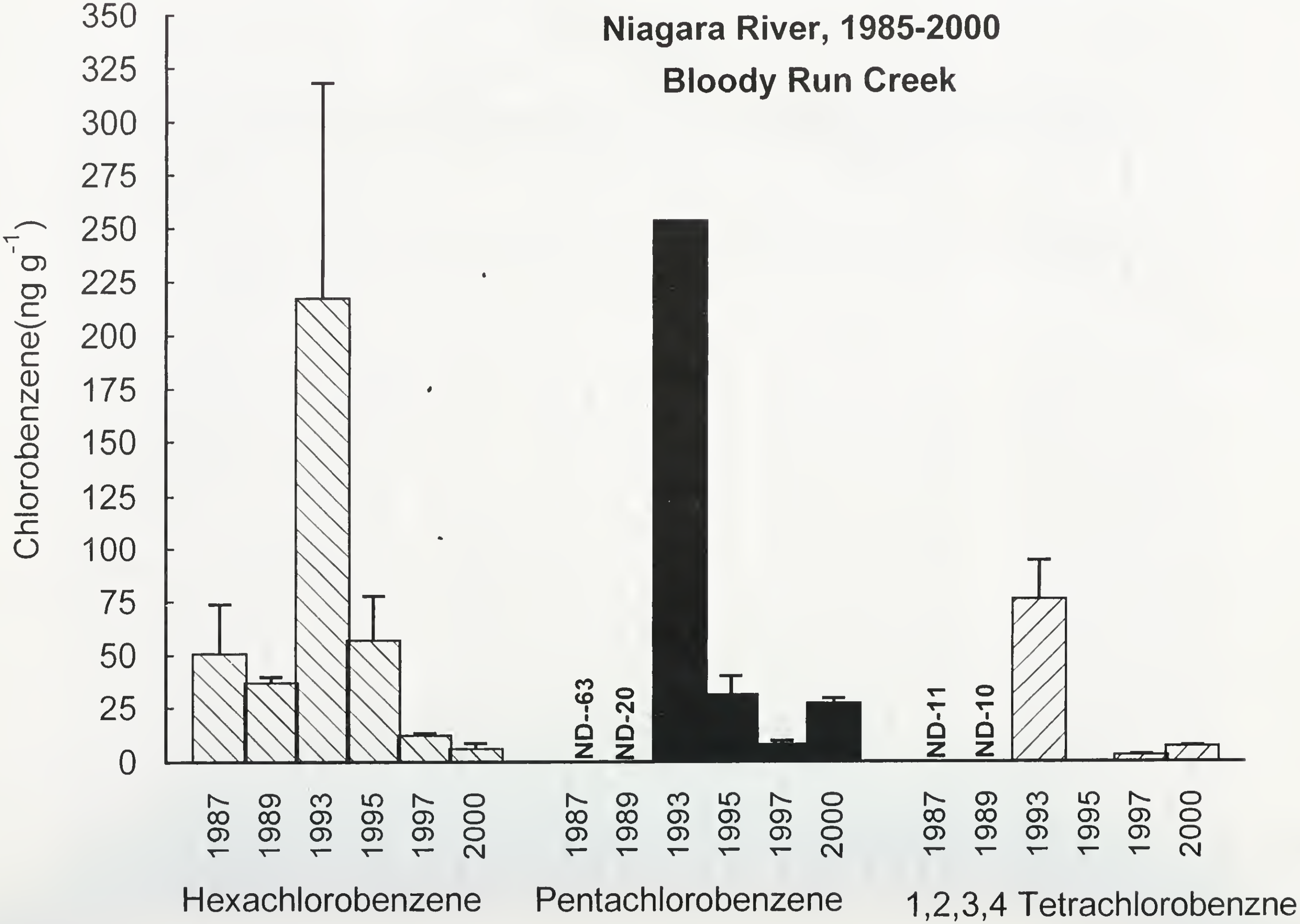
Trace concentrations of 2,3,6- and 2,4,5-trichlorotoluene were detected in mussel tissue from two sewers associated with the Occidental facility (station 42 (Sewer 003) and station 40). Chlorotoluene was a known contaminant in Occidental's effluent (NRTC 1984) and has been consistently detected since 1983 in mussels deployed at the various outfalls associated with the Occidental Chemical Corporation property. Although there was considerable variability between replicate samples in previous surveys (1989 - 1995), concentrations at the 003 outfall were consistently low in 1997 and 2000 compared with data since 1989 (Figure 6). Both these compounds were also detected in mussels deployed at the mouth of Bloody Run Creek. This is consistent with data from previous surveys in 1989, 1993 and 1997 suggesting continuing inputs of these compounds. These compounds along with chlorinated benzenes were deposited in the Hyde Park waste site which is the source of contaminants to Bloody Run Creek (USEPA and NYSDEC 2002).

Remediation of the 102nd Street Landfill site by various containment options and the removal of contaminated sediment from the river began in 1996. Before remediation, mussels deployed at the 102nd Street Landfill in the contaminated sediment had detectable concentrations of trichlorobenzenes and often the highest concentrations of hexa, penta and tetrachlorinated benzenes relative to other sites monitored in the surveys. The absence of these contaminants from the mussel tissue in 1997 and again in 2000 was noteworthy and was likely due to the removal of the contaminated sediment from the surrounding area and installation of a slurry wall around the site to prevent contaminants from leaking into the river (USEPA and NYSDEC 2002).

Figure 3: Caged Mussel Tissue Concentrations (mean±SD, n=3)

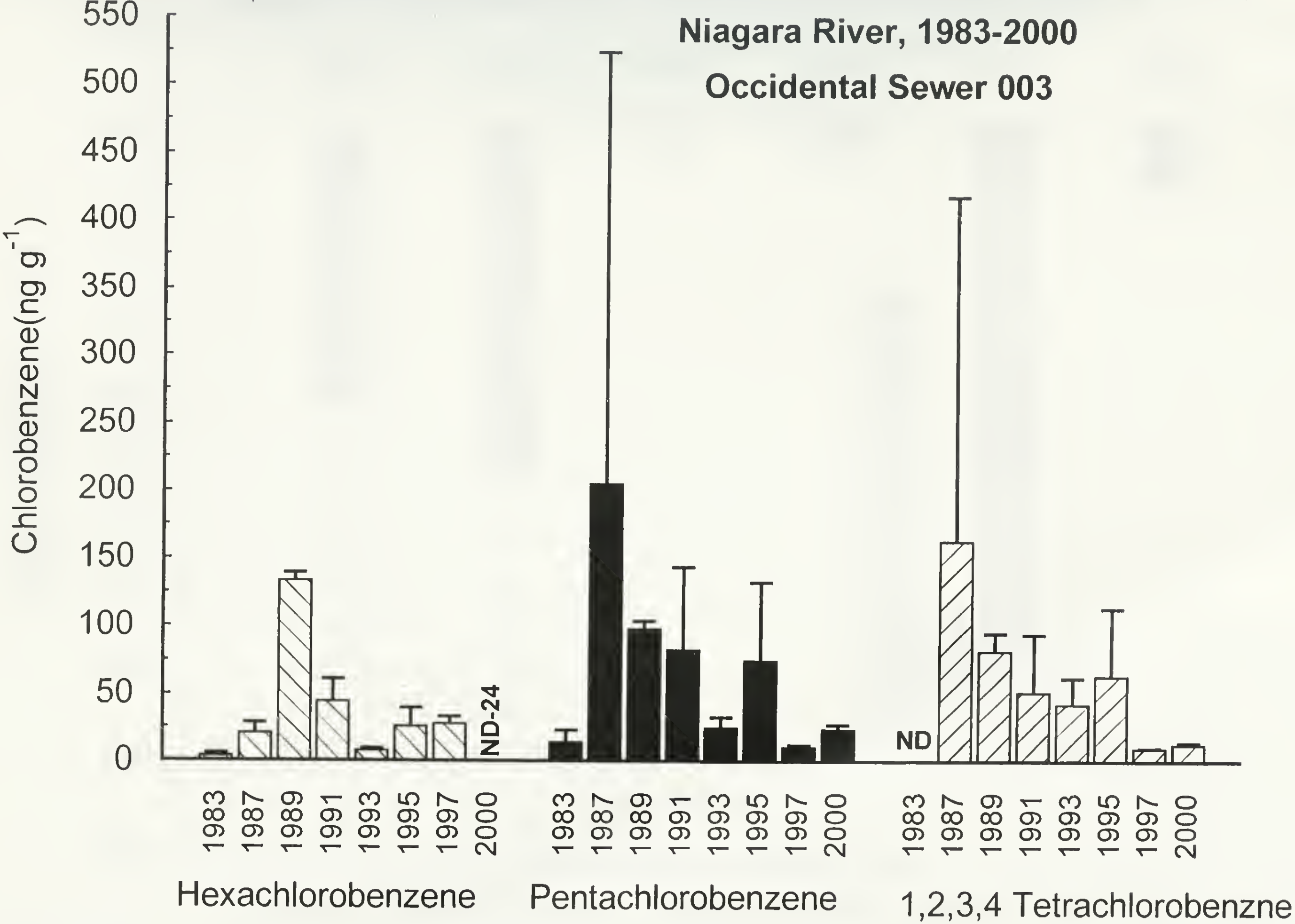
Niagara River, 1985-2000

Bloody Run Creek



ND= Not Dectected

Figure 4: Caged Mussel Tissue Concentrations (mean±SD, n=3)

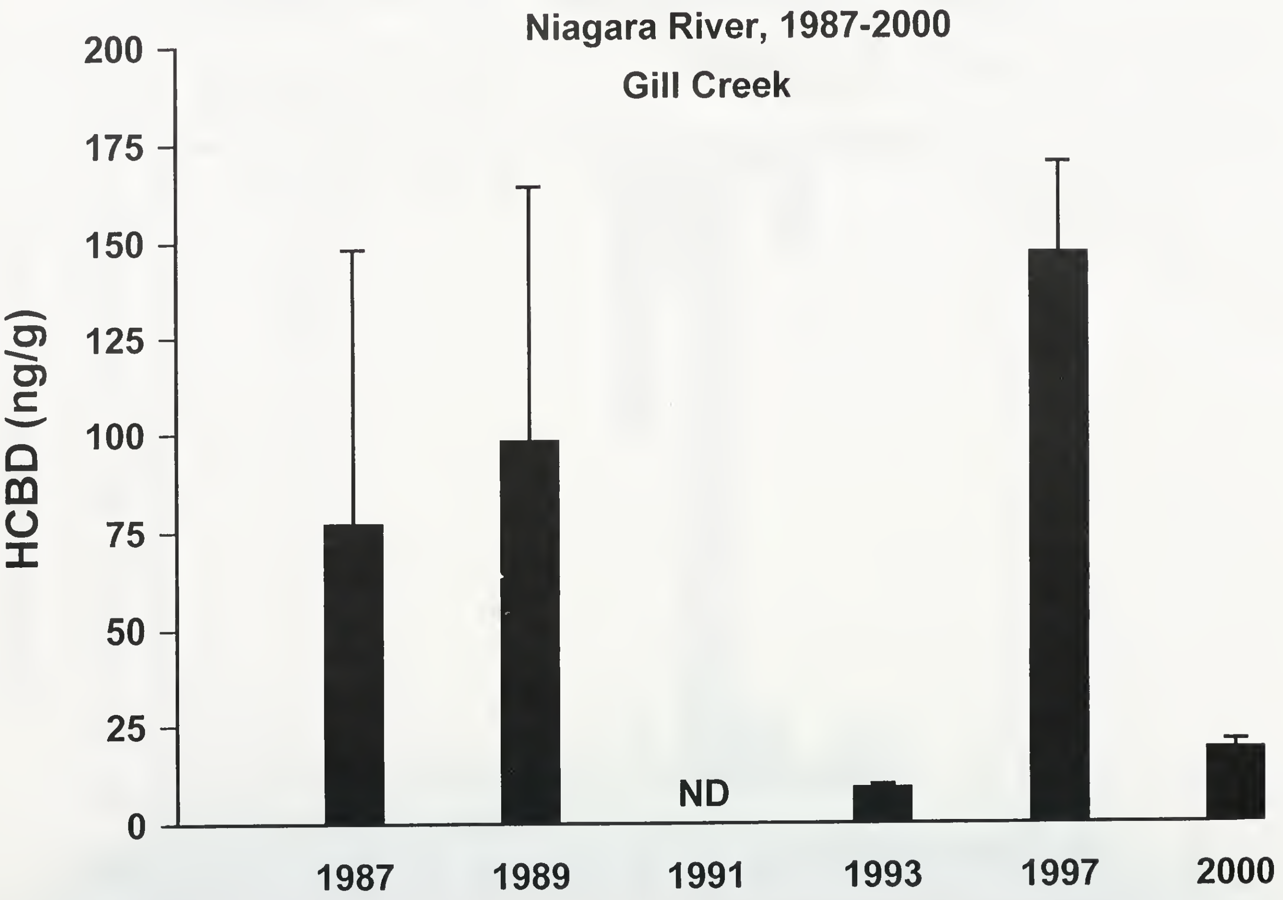


Niagara River, 1983-2000

Occidental Sewer 003

ND= Not Dectected

Figure 5: Caged Mussel Tissue Concentrations (mean+/-SD; n=3)



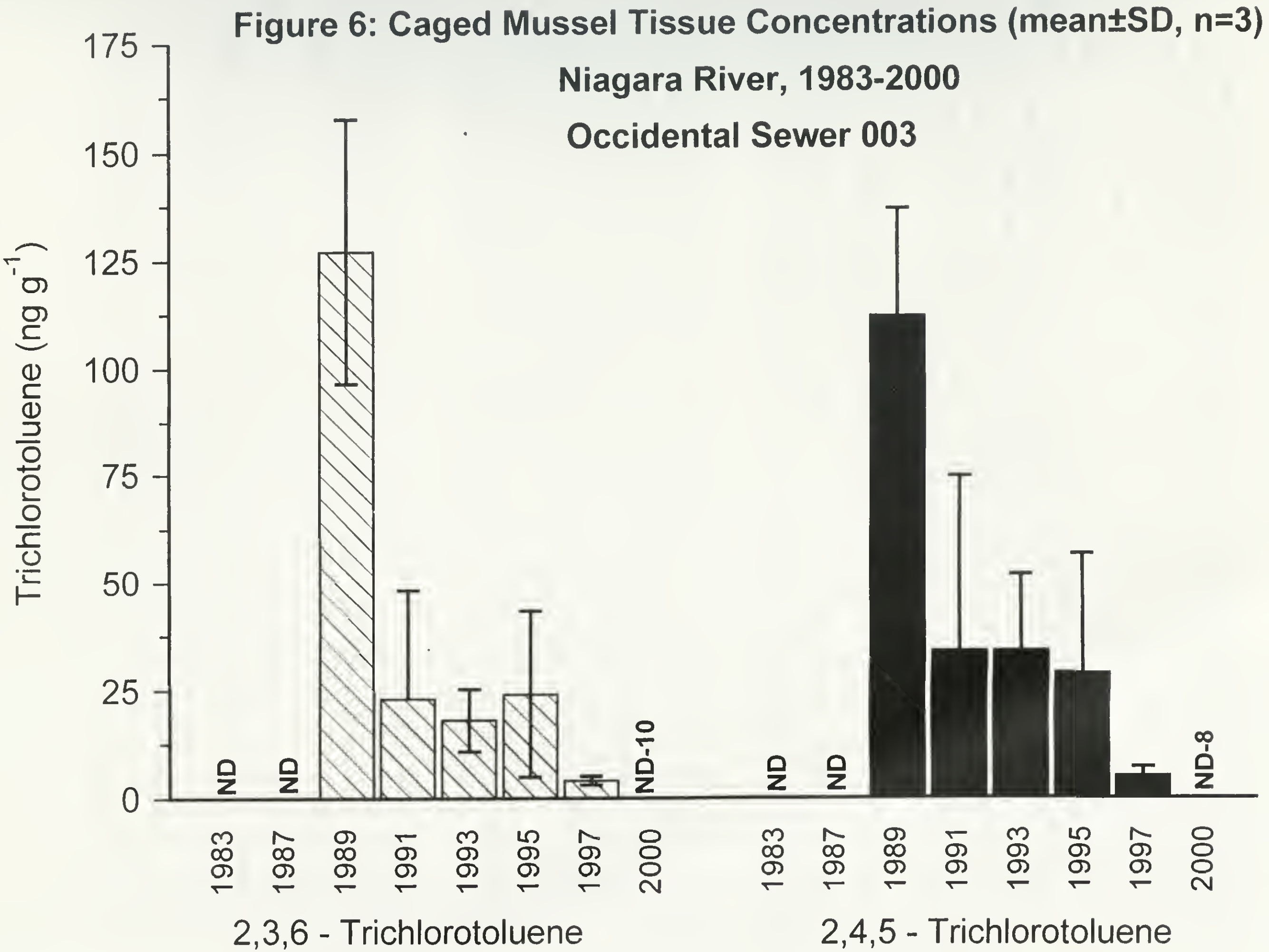


Figure 6: Caged Mussel Tissue Concentrations (mean±SD, n=3)

Niagara River, 1983-2000

Occidental Sewer 003

ND= Not Dectected

Concentrations of chlorinated benzenes in mussels deployed at the Pettit Flume inlet cove were low in 1995, 1997 and 2000 relative to previous years of sampling before the remediation of the cove (Anderson *et al.* 1991; Richman 1992; Richman 1993; Richman 1994; Richman 1997). Most notable were mussel tissue concentrations of hexachlorobenzene, pentachlorobenzene and 1,2,3,4 tetrachlorobenzene. Only pentachlorobenzene was present at detectable concentrations in mussel tissue in 2000. The remaining chlorinated benzenes were present only at trace concentrations. By removing contaminated sediment from the cove an important non-point source of contaminants to the Niagara River was eliminated. However, high concentrations of dioxins and furans were detected in deployed mussels and sediment collected from the cove in 1997 and again in 2000 suggesting that the flume is still an active source of dioxins and furans. This will be discussed in greater detail in the next section.

Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

Dioxins and furans were analysed in sediment collected from nine stations, and in one composite mussel sample (four mussels per site), from each of eight stations as well as the Balsam Lake control mussels (Table 5 & 6).

Toxicity Equivalency Factors (TEFs) have been used as a measure to express the toxicity of different dioxins and furans on a common basis. TEFs were assigned to individual dioxins and furans on the basis of how toxic they were in comparison with the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (T4CDD), which was assigned the value of 1.0. When concentrations of individual isomers are converted to toxicity equivalents of 2,3,7,8-T4CDD they are then summed to yield a total toxic equivalents (TEQ). The World Health Organization TEFs for the protection of humans and mammals from August 1997 were used for the calculations for both sediment and mussels (van den Berg et al. 1998). Where appropriate, the calculated TEQs can be compared with sediment quality guidelines and tissue residue guidelines, to help put the values in perspective.

With the exception of low concentrations of dioxin-like PCBs, dioxins and furans were not detected in the Balsam Lake control mussels or the mussels deployed at Fort Erie and the Chippawa Channel. Mussels deployed at NOTL only had detectable concentrations of tetrachlorinated dibenzo-p-dioxin (1.6 pg/g) along with low concentrations of the dioxin-like PCBs (Table 5).

Sediment concentrations of dioxins and furans at Fort Erie and the Chippawa Channel were low (TEQ: 2.4 pg/g and 0.22 pg/g respectively), and similar to concentrations measured at Fort Erie in 1995 (TEQ 1.3 pg/g), and 1997 (11.3 pg/g) (Table 6). Sediment was not collected from NOTL in 2000 but TEQs from 1993 and 1995 were low (14.8 and 14.2 pg/g respectively). Ontario does not have a Sediment Quality Guideline (SQG) for dioxins and furans at present, however, the interim SQG for the No Effect Level for 2,3,7,8-

Table 5: Concentrations of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in mussels (pg/g wet wt.) deployed in the Niagara River for 21 days, 2000. N=1 (composite of four mussels)

Station Description		Balsam Lake	NOTL		Pettit Flume (upstream)		Pettit Flume (downstream)		Pettit Flume (site B)		Bloody Run Creek (upstream)	Bloody Run Creek		Fort Erie	Chippawa Channel
Station number		Control	11-2-9		5-2-185		5-2-187		5-2-186		11-2-18	11-2-17		5-2-203	5-2-51
2378-tetrachlorofuran		.	.		.				75		.	.			
12378-pentachlorofuran		.	.		.		.		20		.	.		.	.
23478-pentachlorofuran		.	.		.		3.2		52		.	.		.	
123478-hexachlorofuran		.	.		.		9.9		220		.				.
123678-hexachlorofuran		.	.		.		1.7		41		.	.		.	.
234678-hexachlorofuran		.	.						13		.	.			.
123789-hexachlorofuran									.						.
1234678-heptachlorofuran			.		.		11		250		.	.		.	.
1234789-heptachlorofuran		.	.						7.9		.	.			
Octachlorofuran							12		240		.	.		.	.
2378-tetrachlorodioxin		.	.		.		.		6.5		.	23			.
12378-pentachlorodioxin		.	.				.		5		.	.			.
123478-hexachlorodioxin							.		2.7		.	.		.	.
123678-hexachlorodioxin			.		.				5 4		.	1.5		.	.
123789-hexachlorodioxin		.	.				.		.		.	.			.
1234678-heptachlorodioxin		.	.		.		0.96		13			.		.	.
Octachlorodioxin		.	.		7.9		.		41		.	.			.
3,4,4',5-tetrachlorobipheny	PCB081	.	.		3.7		1.1		3.1		.	11			.
3,3',4,4'-tetrachlorobiphen	PCB077	32	6.3		110		59		31		.	39		4.3	4 5
2'3,4,4',5-pentachlorobiphenyl	PCB123	19	12		60		41		77		7 7	23		7.3	5.3
2,3'4,4',5-pentachlorobiphenyl	PCB118	380	250		1200		740		800		170	420		110	85
2,3,4,4',5-pentachlorobiphenyl	PCB114	13	.		35		27		66		6 4	36		2 5	1.8
2,3,3'4,4'-pentachlorobiphenyl	PCB105	170	96		540		340		300		83	240		51	35
3,3'4,4',5-pentachlorobiphenyl	PCB126	4 9	1.2		4 5		3.9		12		.	4.7		1 3	
23',44',55'-hexachlorobiphenyl	PCB167	43	9.9		120		35		87		9.4	15		.	.
2,3,3'4,4'5-hexachlorobiphenyl	PCB156	.	.		93		75		230		18	27		.	.
2,3,3'44'5'-hexachlorobiphenyl	PCB157	16 •	6.7		24		16		31		3.9	11			
3,3'4,4'55'-hexachlorobiphenyl	PCB169	.	.		.		.		.		.	.		.	.
233'44'55'-heptachlorobiphenyl	PCB189	10	.		11		7 2		42		2.3	.		.	
Tetrachlorodioxin; total			1.6	I1	9.2	I3	9.5	I1	310	I9	.	23	I1	.	.
Tetrachlorofuran; total			.		1	I2	18	I4	580	I15	.	3.3	I1		.
Pentachlorodioxin; total			.				.		98	I7	.	.		.	.
Pentachlorofuran; total			.				25	I7	560	I12	.	.		.	.
Hexachlorodioxin; total			.				.		53	I5	.	1.5	I1		
Hexachlorofuran; total			.				18	I4	540	I8	.	.		.	.
Heptachlorodioxin; total			.		0.68	I1	0.96	I1	21	I2	.	.		.	
Heptachlorofuran, total			.				11	I1	350	I4	.	.		.	
TEQ (pg/g)		**0.57**	**0.16**		**0.72**		**3.45**		**78.44**		**0.04**	**23.73**		**0.15**	**0.01**

* Number of isomers detected in the congener group

" " Compound was below the detection limit

Table 6: Concentrations of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in sediment collected from the Niagara River, 2000

Station number	Chippawa Channel 5-2-51 pg/g dry		Pettit Flume (upstream) 5-2-185 pg/g dry		Pettit Flume (site B) 5-2-186 pg/g dry		Pettit Flume (downstream) 5-2-187 pg/g dry		Fort Erie 5-2-203 pg/g dry		Gill Creek (upstream) 5-15-22 pg/g dry		Bloody Run Creek 11-2-17 pg/g dry		Bloody Run Creek (upstream) 11-2-18 pg/g dry		Two Mile Creek 5-20-197 pg/g dry	
2378 TCDF	.		12		8400		100		.		40		95		7.4		25	
12378PCDF	.		.		3700		47		.		15		47		.		5.7	
23478PCDF	.		6.6		10000		160		.		17		180		5.8		13	
123478 H6CDF	.		48		140000		2500		.		300		1500		54		41	
123678 H6CDF	.		11		22000		380		.		46		280		8.6		14	
234678 H6CDF	.		5		6100		91				7		61		2.5		9.8	
123789 H6CDF	.		.		190		3.8		.		.		.		.		.	
1234678 HpCDF			180		450000		7800		.		420		910		110		140	
1234789 HpCDF	.		5.2		15000		270				150		290		4.7		12	
O8CDF (total)	.		250		1100000		14000				1600		3800		140		300	
2378 TCDD	.		0.59		640				2.2		3 8		2800		32		3.1	
12378 PCDD	.		.		1200		17				6.2		59		.		4.8	
123478 HxCDD	.				1200		19				13		190		.		4.1	
123678 HxCDD			.		2700		36		.		69		2400		11		18	
123789 HxCDD			4.3		2000		25		.		39		1400		6.1		12	
1234678 HpCDD	6.8		92		15000		250		9		1100		11000		41		220	
O8CDD (total)	120		740		33000		1100		67		12000		8500		52		2300	
PCB081	.		29		260		21		1.7		84		840		38		220	
PCB077	13		1100		1300		540		20		2300		3100		360		10000	
PCB123	5		330		1200		150		15		350		1100		67		3300	
PCB118	110		5600		19000		3000		250		11000		21000		1600		98000	
PCB114	.		150		5000		120		6		360		2800		61		2100	
PCB105	49		2900		6200		1400		110		5100		15000		790		38000	
PCB126	1.2		34		410		18				86		560		38		280	
PCB167	.		250		2000		180		15		300		1000		38		3400	
PCB156	11		510		9000		370		39		1000		1900		86		8800	
PCB157	.		140		940		79		5		240		1100		12		2200	
PCB169	.		.		110				.		6.4		99		8.5		9 1	
PCB189	1.2		72		3200		72		5.1		180		350		8		560	
Tetrachlorofuran	.	*	78	I18*	62000	I19	750	I18	1 8	I2	240	I20	790	I17	60	I18	270	I18
Pentachlorofuran	.		140	I11	120000	I17	1800	I12	5.7	I4	270	I13	2900	I13	66	I11	370	I13
Hexachlorofuran			190	I13	330000	I15	5100	I15	.		650	I12	4100	I13	120	I12	300	I13
Heptachlorofuran	.		270	I4	580000	I4	10000	I4	4.3	I1	860	I4	2100	I4	160	I4	340	I4
Tetrachlorodioxin			16	I5	40000	I16	320	I10	2.2	I1	36	I5	2900	I4	45	I4	44	I6
Pentachlorodioxin			9.2	I3	31000	I12	310	I10	.		45	I4	1500	I11	12	I4	15	I2
Hexachlorodioxin	.		53	I6	42000	I8	460	I8	1.7	I1	320	I7	11000	I8	56	I6	160	I8
Heptachlorodioxin	15	I2	210	I2	26000	I2	460	I2	15	I2	1500	I2	16000	I2	63	I2	440	I2
TEQ (pg/g)	**0.2**		**19.6**		**30,250**		**502**		**2.4**		**100**		**3,731**		**50**		**81**	
TOC (mg/g)	5		23		120		33		9		14		7		5		39	
% Silt/clay	13		13		54		34		11		61		36		30		54	
% Sand	87		84		46		65		89		39		64		68		46	
% Gravel	0		4		0.4		1		0		0.2		0.3		1		0 1	

* Number of isomers detected in the congener group

"." Compound was below the detection limit

T4CDD has been set at 25.7 pg/g and the Canadian Environmental Quality Guideline "probable effect level" has been set at 21.5 pg/g (CCME, 2001).

Sediment collected from Two Mile Creek and from the station in Gill Creek upstream of the creek mouth were contaminated with dioxins and furans. The TEQs for the sediment samples were 81 and 100 pg/g respectively. The sediment collected from Gill Creek is of particular interest since the area was remediated in 1998. This data suggests a recent source of dioxins and furans.

Bloody Run Creek

Bloody Run Creek and the nearby seepages which run down the face of the Niagara Gorge were historically contaminated from the Hyde Park landfill. Prior to site remediation in 1994, the drainage from the Hyde Park landfill was a major source of dioxin contamination to the Niagara River (Gradient Corporation 1988). Bloody Run Creek passes through the Niagara gorge and discharges to the Niagara River at the base of the gorge. Due to difficulties related to site access this part of the creek and the bank of the Niagara River have not been remediated. Historically there have been high concentrations of dioxins and furans in sediment and deployed mussels in this area.

At the mouth of Bloody Run Creek concentrations of dioxins and furans in mussels were lower in 2000 (TEQ: 23 pg/g), than concentrations detected in 1994,1995 and 1997(TEQ range: 57 to 125 pg/g). However, calculated TEQs were still higher than samples collected at uncontaminated sites (e.g. about 100 m upstream of Bloody Run Creek in the Niagara River, at Fort Erie and the Chippawa Channel where dioxins and furans were not detected in mussel tissue). The TEQ was also greater than the CCME Canadian Environmental Quality Guideline for protection of mammals (0.71 ng TEQ/kg diet) and birds (4.75 ng TEQ/kg diet). The variability in tissue concentrations in mussels between surveys could be due to the location of the cages and proximity to the creek mouth. A rock slide in 1994 buried the location of the mouth of the creek. The creek flow was low when the mussels were deployed and the flow disappeared under the rock and rubble along the shoreline. The mussels were placed in the same location used in previous surveys, however, this may not have been in the vicinity of the creek mouth. Nevertheless, it is clear that dioxins and furans are bioavailable and entering the Niagara River at this location.

Dioxins and furans in exposed shoreline (bank) sediment were also lower in 2000 than in previous sediment surveys. In 1997 the TEQ was 58,543 pg/g compared with a TEQ of 3,732 pg/g in 2000. The sediment along the shoreline has not been remediated so the 2000 data likely reflected the variability in local contamination rather than an improvement or decrease in sediment contamination. Results from an EPA sediment survey in 1999 also showed that the sediment contamination was variable (Coleates 1999). The selection of a site for the collection of sediment is highly variable between surveys and is dependant on the water level of the Niagara River at the time of sampling. As well, the rock slide in the gorge in 1994 altered the topography along the shoreline at the sampling station. Highly contaminated sediment was exposed in some spots due to the rock slide and buried in other locations. The sediment concentrations in 2000 were high relative to the Bloody Run Creek upstream "reference" station (100 m upstream of the Bloody Run Creek site in the Niagara River), where sediment concentrations were 75 times lower (TEQ 50 pg/g). Bloody Run Creek is still considered a source of dioxins and furans to the Niagara River and requires additional long term monitoring in the future.

Characteristic of the congener/isomer patterns for Bloody Run Creek all the tetra-dioxin was in the form of 2,3,7,8-tetrachlorodibenzo-p-dioxin which is the most toxic form of dioxin. The ratio of the 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ to the sediment total TEQ remained constant at about 0.76.

Pettit Flume

The Pettit Flume discharges storm water to the Pettit Flume inlet cove. Historically it received waste water from the Occidental Chemical Corporation Durez Division and surrounding hazardous waste sites (Geologic Testing Consultants LTD. 1984). Prior to the remediation of the cove and containment of contaminants at the waste site, the cove was filled with waste products which included chlorinated phenols, chlorotoluene, other organic and inorganic compounds and phenol tar containing chlorinated benzenes (Interagency Task Force on Hazardous Waste 1979; Raven 1991; USEPA and NYSDEC 2002). As well, high concentrations of dioxins and furans were routinely detected in sediment collected from the cove and in deployed mussels. Site remediation was completed in 1995 and as discussed above, concentrations of chlorinated benzenes in deployed mussels have been consistently low since that time.

However, high concentrations of dioxins and furans were detected in mussels and sediment from the Pettit Flume inlet cove in 1997 suggesting that the area had been re-contaminated (Richman 1999). Accordingly, the contaminated sediment was removed in the spring of 2000 (USEPA and NYSDEC 2002). However, high concentrations of dioxins and furans have again been detected in deployed mussels and sediment collected in July 2000.

Although the concentrations of dioxins and furans in mussels and sediment were lower than concentrations detected in 1993 prior to the original remediation of the cove, they were still uncharacteristically high. The concentrations in 2000 were even higher than the concentrations in 1997 which precipitated the additional clean-up action in 2000. The TEQ for mussel tissue in 2000 was 77 pg/g. For comparison, the TEQ at the reference site immediately upstream of the cove was 0.001 pg/g. The sediment TEQ was 30,250 pg/g which suggests extremely contaminated sediment. The TEQ at the upstream site was 20 pg/g.

The high concentrations in mussel tissue suggest that these compounds were still bioavailable in this cove. Since fish, other aquatic biota and waterfowl move freely in and out of the cove to feed, the cove is a source of dioxins to indigenous biota. The concentrations are much higher than the Canadian tissue residue guidelines. High concentrations of dioxins and furans were also present in sediment collected from a station just downstream of the cove (TEQ: 502 pg/g), suggesting sediment transport from the cove. Of most concern, is that the site was remediated only a few months prior to this survey.

The isomer patterns in the sediment and mussels were consistent with previous samples from 1993 before remedial activities which suggests a common source (Figure 7 & 8).

Of particular concern are concentrations of 2,3,7,8 T4CDD. This compound was detected in sediment from the Pettit Flume upstream station at low concentrations (0.6 pg/g) while concentrations in sediment from the Pettit Flume site were 640 pg/g. In general, concentrations of 2,3,7,8 T4CDD in the Great Lakes Basin (for example Lake Superior and Lake Erie) tend to be less than 10 pg/g (MOE unpublished data; Richman 2001). A sediment survey of 49 stations in Lake Ontario resulted in a mean 2,3,7,8 T4CDD concentration of 68 pg/g with only one sample having a maximum concentration of 350 pg/g (U.S. EPA *et al.* 1990).

Long Term Deployment of Caged Mussels

Mussels were deployed for up to 105 days at the mouth of Two Mile Creek, located on the American side of the upper Niagara River. Two Mile Creek was chosen to study the bioaccumulation of PCBs by caged mussels since the creek was known to have PCB contaminated sediment. One sediment sample was collected during the survey and the total PCB concentration was 1.6 *u*g/g (percent silt/clay was 53% and TOC was 39 mg/g).

Three randomly selected mussels were retrieved after exposure for 1, 2, 3, 7, 14, 21, 42, 63, 84 and 105 days (15 weeks). These mussels are referred to as "long term". On day 21, 16 additional mussels were deployed in separate cages, and three mussels from this group were randomly selected on each of days 42, 63, 84 and 105 noted above (i.e. exposure times of these mussels was for 21,42, 63 and 84 days respectively). This group of mussels are referred to as "group A". Similarly, on day 42 above, 12 additional mussels were deployed in another cage and three mussels from this group were randomly selected on each of days 63, 84 and 105 (i.e. exposure times of these mussels was for only 21, 42, and 63 days respectively). This group is referred to as "group B". Mussels were analysed for total PCBs, organochlorinated pesticides, chlorinated benzenes and percent lipid. Data are provided in Table 7 and Table 8. A regression analysis on total PCB concentrations and percent lipid levels produced a r^2 of 0.05. This poor relationship was likely due to the limited range in percent lipid (range: 0.1 to 0.86% median: 0.29%). Given this, it was not considered appropriate to lipid normalize the data.

Figure 7: Isomer Patterns in Mussels-Pettit Flume

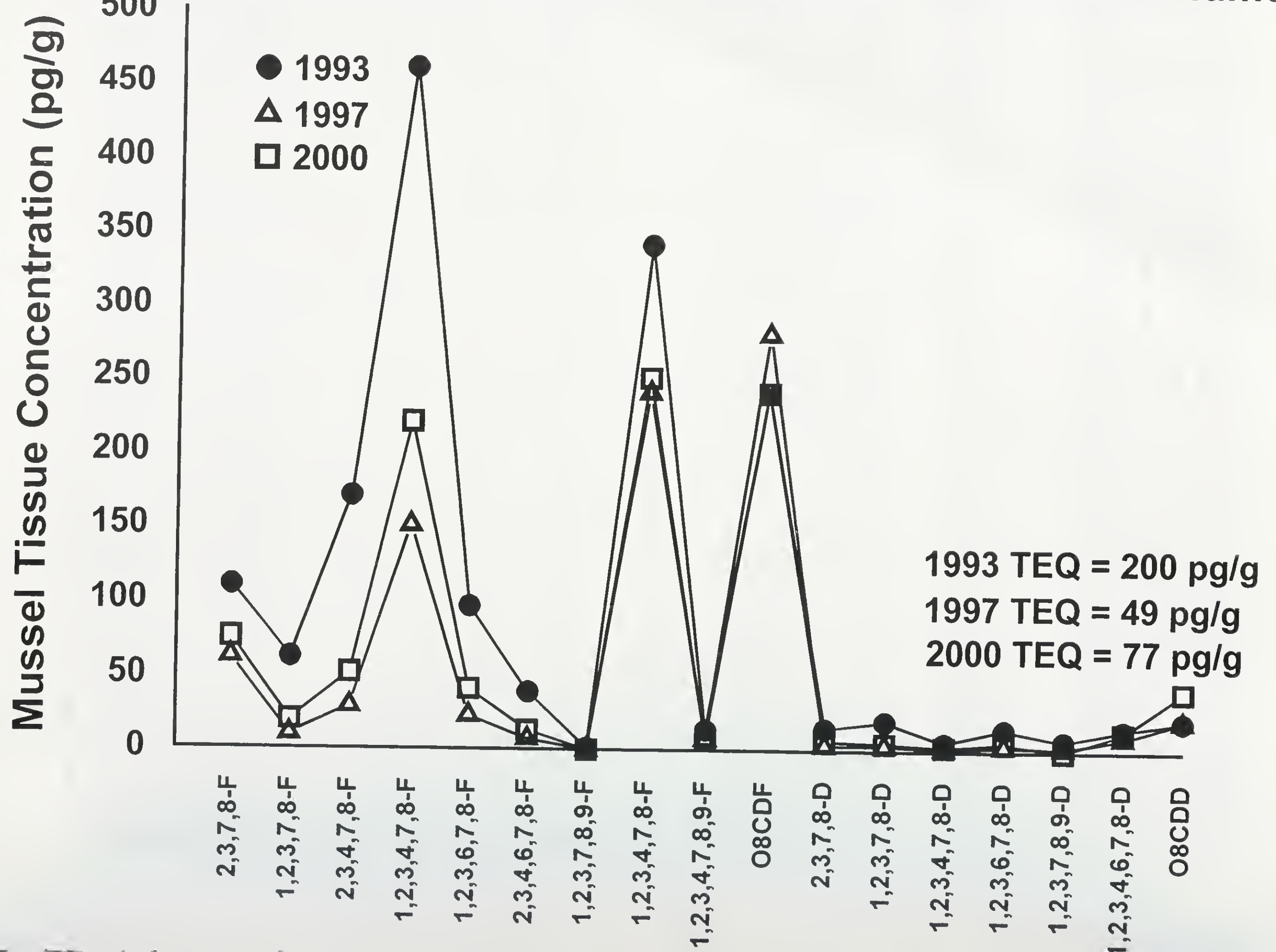
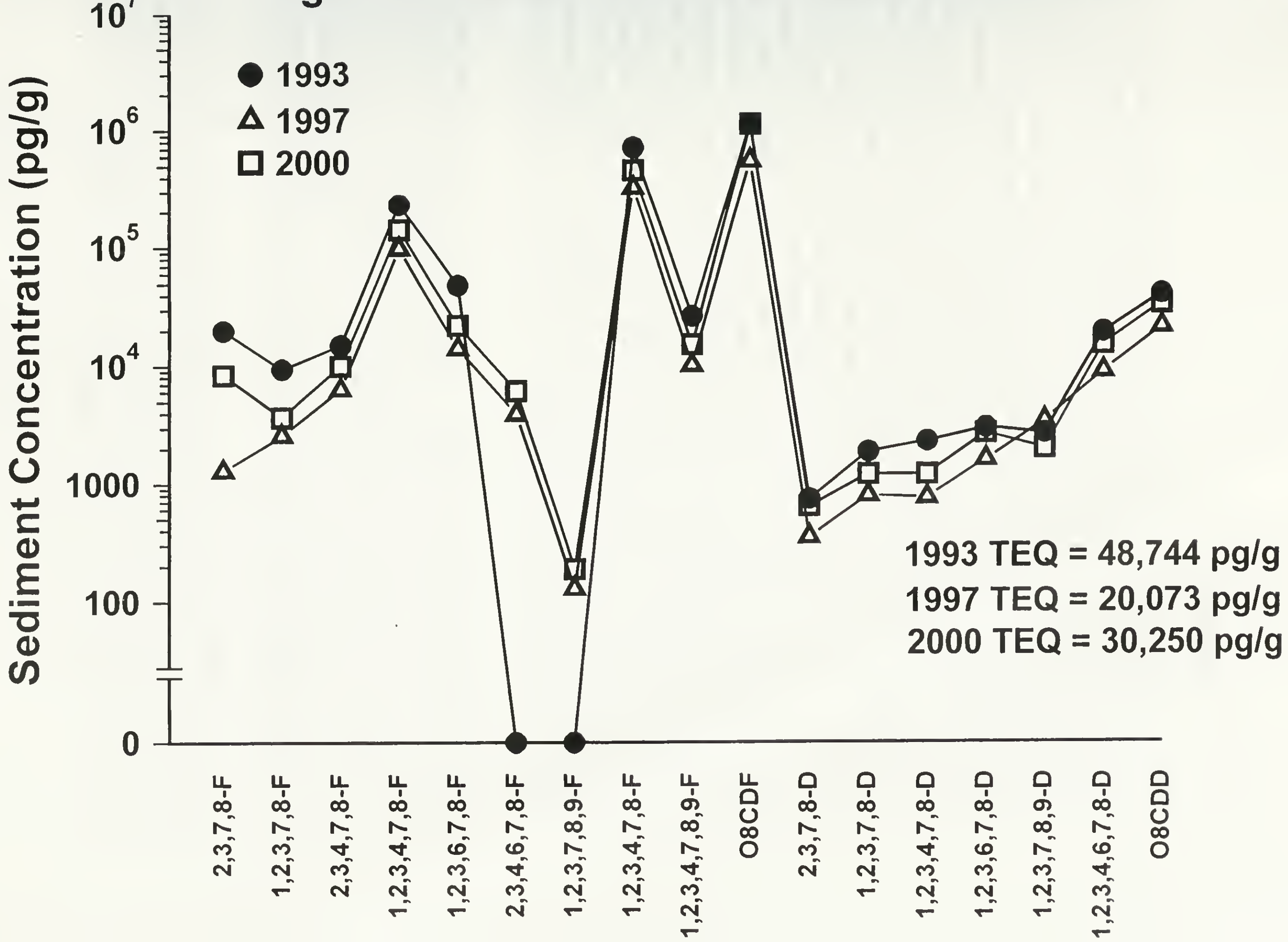


Figure 8: Isomer Patterns in Sediment-Pettit Flume



Polychlorinated Biphenyls (PCBs)

Tissue concentrations of PCBs were below the detection limit (20 ng/g) for the first day of sampling, followed by an increase within the next 24 and 70 hours (range: 40 - 80 ng/g), which was consistent with data collected from Two Mile Creek in 1997 (Richman 1999). Total PCB tissue concentrations were similar from day 7 until day 42 (range: 60 - 100 ng/g) (Table 7; Figure 9), with only a small increase over time suggesting that the mussel tissue concentrations were entering a state of equilibrium with their environment. Between 42 and 63 days of deployment (from August 22 to September 12, 2000), exposure to PCBs may have changed since tissue concentrations increased to a mean of 160 ng/g (SD 34.6; range 140 - 200 ng/g). Mussels retrieved on day 84 and 105 had similar PCB concentrations as those exposed for 63 days (mean: 113 ng/g and 167 ng/g respectively), possibly indicating that a new steady state had been reached. Variability in the data was large for these three sampling dates but, overall, concentrations were higher than those detected within the first 42 days of exposure. The mean concentration from day 63 to 105 was 147 ng/g (SD 36.1 ng/g), compared with the overall mean from day 2 to 42 days which was 79 ng/g (SD 18.8 ng/g). Since PCB concentrations in water were not measured, we can only speculate on the reasons for the increase in PCB tissue concentrations in mussels retrieved on September 12th, 2000. One possibility is rainfall. On September 8th (four days before the 63 day retrieval), 48.6 mm of rain fell which was the largest rain event from July through October (Environment Canada 2000) (Figure 13). PCB loadings may have increased due to the rainstorm either through the flushing of storm sewers located upstream in the creek or through disturbances to the contaminated sediment. Wet and dry weather sampling of water from Two Mile Creek by NYSDEC in 2000 confirmed the presence of PCBs at four locations in the creek with concentrations being higher during wet weather events (Williams and O'Shea 2003).

A similar pattern was observed in the group A and B mussels which were deployed on day 21 and day 42 of the "long term" experiment. The first set of mussels deployed on day 21 (group "A"), were retrieved 21 days later. Mean tissue concentrations (87 ng/g, SD 11.5), were similar to the mussels that had been deployed in the "long term" experiment for either 21 (93 ng/g, SD 11.5 ng/g) or 42 days (100 ng/g, SD 0), verifying that 21 days of exposure was sufficient for mussels to reach equilibrium (Figure 10). The tissue concentrations of the group "A" mussels then increased (from a mean of 87 ng/g after 21 days to a mean of 120 ng/g, SD 20 ng/g), which was similar to the observed increase in tissue concentrations in the 63 day "long term" experiment.

Although the increases was not as large, the group "B" mussels which had only been deployed for 21 days at this time also had higher concentrations of total PCBs (mean 113 ng/g, SD 11.5 ng/g), than mussels deployed for 21 and 42 days in the "long term" experiment (93 ng/g, SD 11.5 ng/g and 100 ng/g, SD 0 respectively), and mussels deployed for 21 days in group "A" (87 ng/g SD 11.5) (Figure 11 & 12).

Table 7: Summary of total PCB concentrations (ng/g wet wt.) and percent lipid in caged mussels deployed in Two Mile Creek for up to 105 days, 2000

LONG TERM

Deployment Date	Retrieval Date	Length of Exposure	Total PCB	Percent Lipid	Mean Total PCB	SD
11-Jul-00	12-Jul-00	24 hr	20<W	0.22		
			20<W	0.19		
			20<W	0.68		
11-Jul-00	13-Jul-00	48 hr	60	0.29	**67**	**11.5**
			80	0.11		
			60	0.20		
11-Jul-00	14-Jul-00	70 hr	60	0.17	**53**	**11.5**
			40	0.15		
			60	0.23		
11-Jul-00	18-Jul-00	7 days	100	0.14	**80**	**20.0**
			80	0.29		
			60	0.42		
11-Jul-00	25-Jul-00	14 days	80	0.40	**80**	**0.0**
			80	0.58		
			80	0.29		
11-Jul-00	01-Aug-00	21 days	80	0.20	**93**	**11.5**
			100	0.35		
			100	0.67		
11-Jul-00	22-Aug-00	42 days	100	0.40	**100**	**0.0**
			100	0.19		
			100	0.35		
11-Jul-00	12-Sep-00	63 days	140	0.12	**160**	**34.6**
			200	0.23		
			140	0.10		
11-Jul-00	03-Oct-00	84 days	140	0.42	**113**	**23.1**
			100	0.77		
			100	0.52		
11-Jul-00	24-Oct-00	105 days	200	0.70	**167**	**30.6**
			160	0.54		
			140	0.48		

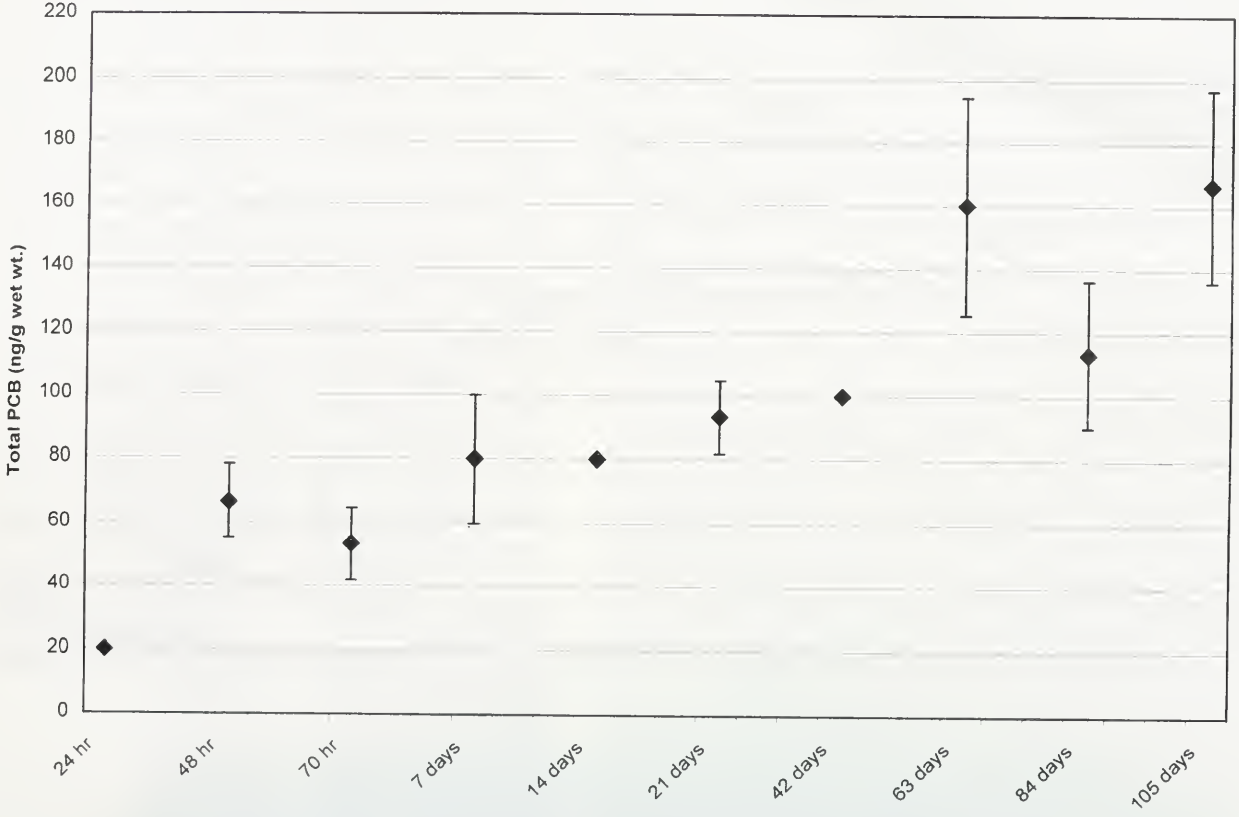
GROUP A

Deployment Date	Retrieval Date	Length of Exposure	Total PCB	Percent Lipid	Mean Total PCB	SD
01-Aug-00	22-Aug-00	21 days	80	0.53	**87**	**11.5**
			80	0.20		
			100	0.40		
01-Aug-00	12-Sep-00	42 days	140	0.11	**120**	**20.0**
			100	0.11		
			120	0.13		
01-Aug-00	03-Oct-00	63 days	140	0.58	**153**	**23.1**
			140	0.25		
			180	0.52		
01-Aug-00	24-Oct-00	84 days	140	0.86	**120**	**20.0**
			100	0.21		
			120	0.35		

GROUP B

Deployment Date	Retrieval Date	Length of Exposure	Total PCB	Percent Lipid	Mean Total PCB	SD
22-Aug-00	12-Sep-00	21 days	100	0.22	**113**	**11.5**
			120	0.24		
			120	0.14		
22-Aug-00	03-Oct-00	42 days	80	0.47	**127**	**50.3**
			180	0.53		
			120	0.53		
22-Aug-00	24-Oct-00	63 days	120	0.62	**133**	**41.6**
			100	0.22		
			180	0.42		

Figure 9: Total PCB Concentrations in Mussels Deployed in Two Mile Creek for 105 Days, 2000



Figue 10: Total PCB Concentrations in Mussels Deployed in Two Mile Creek, 2000

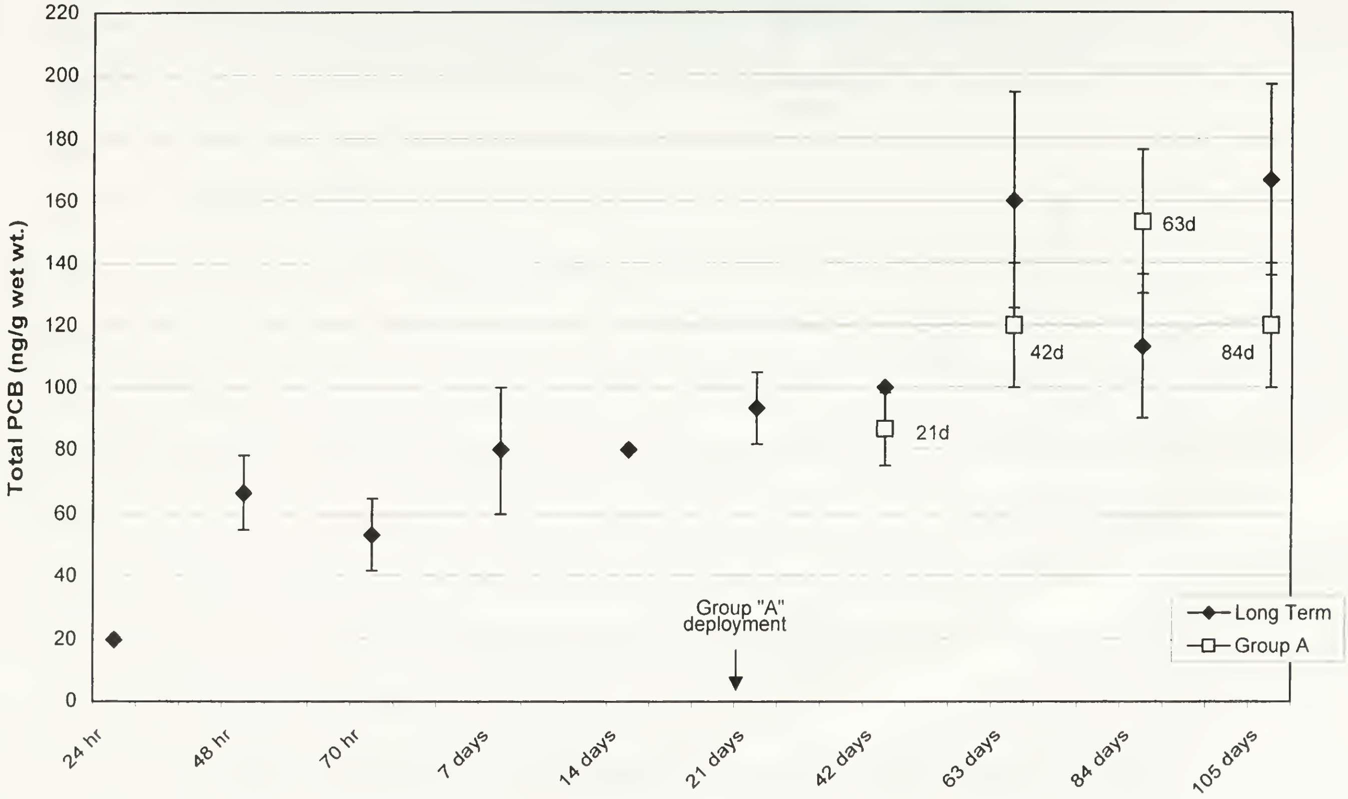


Figure 11: Total PCB Concentrations in Mussels Deployed in Two Mile Creek, 2000

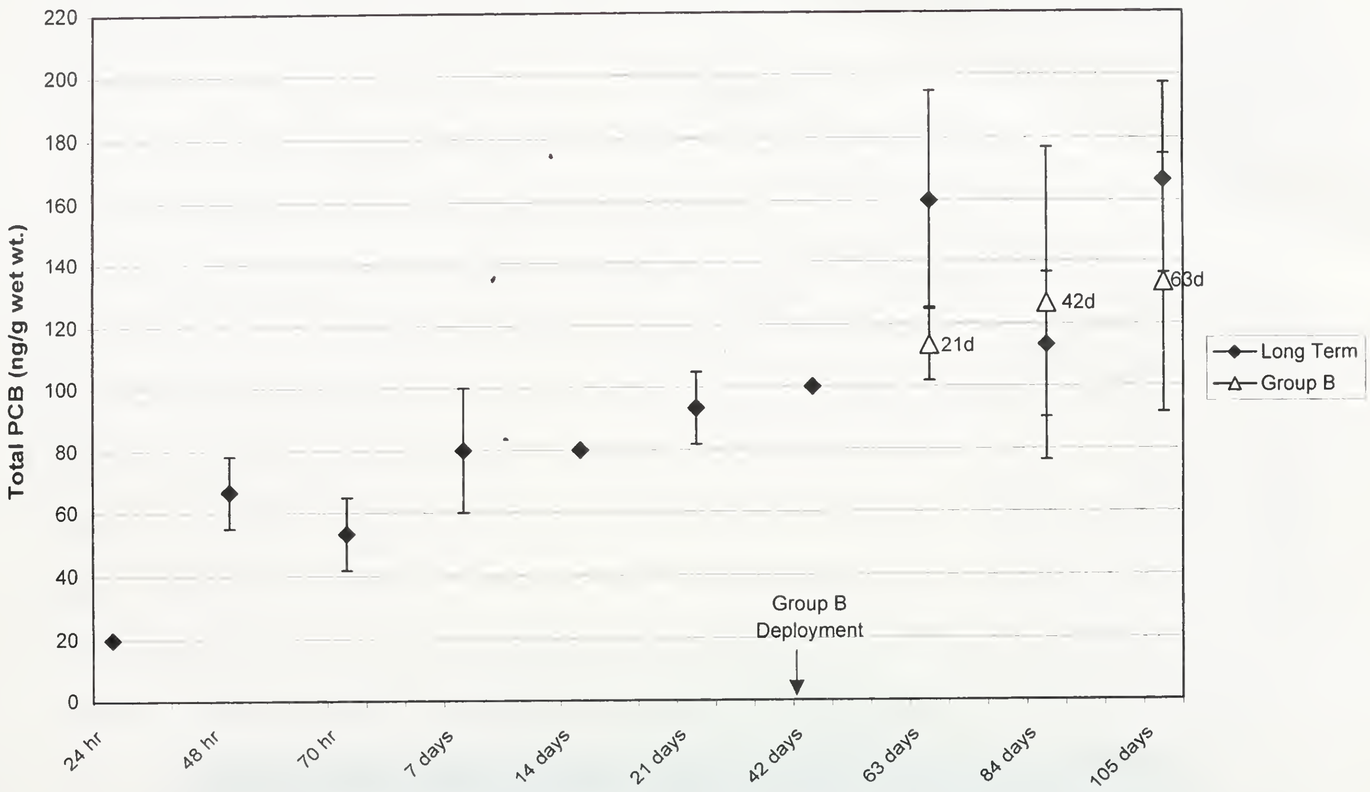


Figure 12: Total PCB Concentrations in Mussels Deployed in Two Mile Creek, 2000

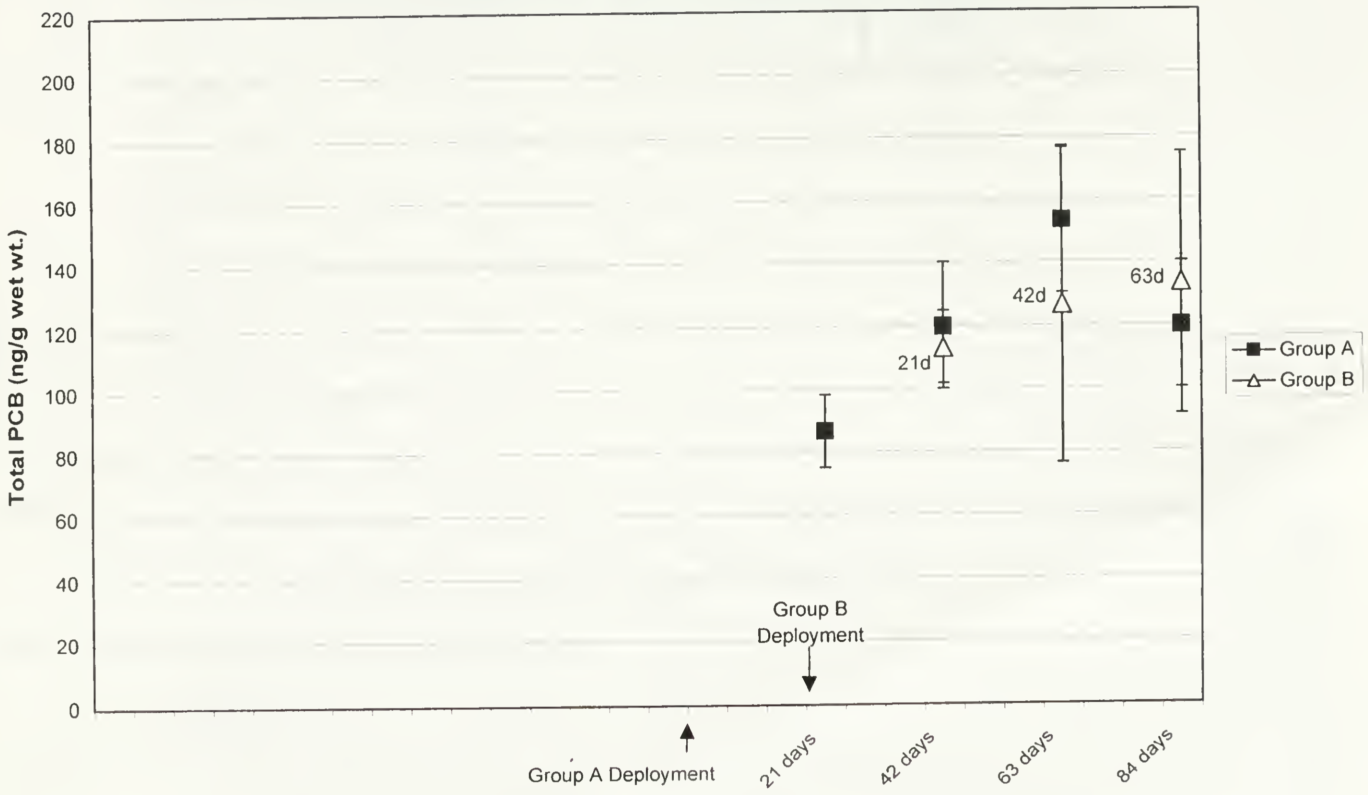
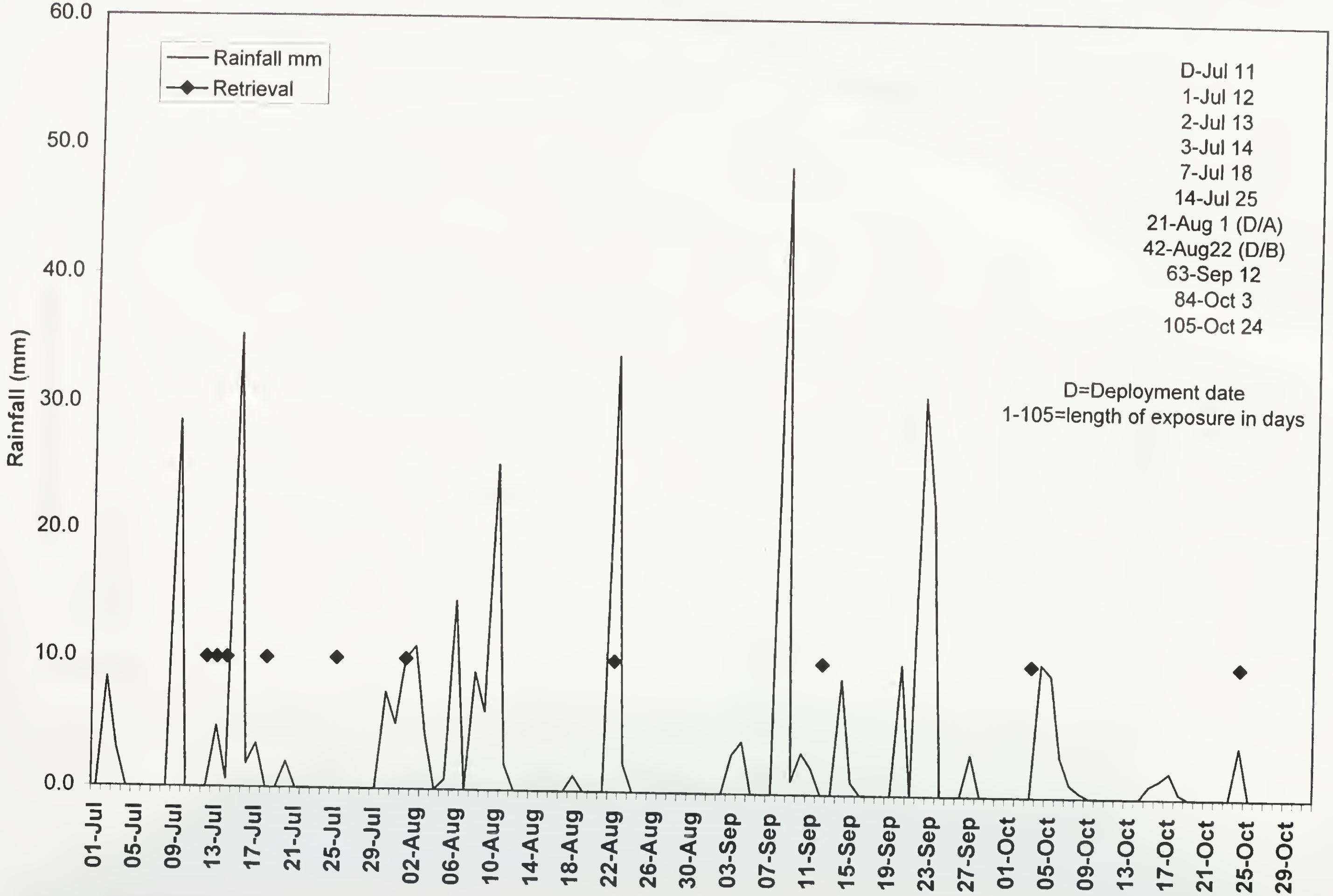


Figure 13: Rainfall (mm) in Fort Erie,Ontario, 2000 and Caged Mussel Deployment/Retrieval Dates



The group "A" mussels retrieved after 63 and 84 days of deployment, and the group "B" mussels retrieved after 42 and 63 days all had similar concentrations to the "long term" mussels deployed for 84 and 105 days, although variability was high.

This general pattern of bioaccumulation (rapid initial uptake within 48 hours and then a slow increase and levelling off of tissue concentrations with time), was representative of a continuous low level source. However, short term contaminant pulses were also reflected in mussels deployed for up to 105 days. This pattern was also observed in mussels deployed for 98 days at the 102nd Street landfill and for 127 days in Cayuga Creek in 1997 (Richman 1999). This same pattern of uptake has been observed in laboratory experiments with algae and freshwater shrimp (*Mysis relict*) exposed to PCBs (Lester and McIntosh 1994; Strange and Swackhamer 1994), although Strange and Swackhamer (1994) cautioned that the rate of uptake and time to reach equilibrium may differ between the lower and higher chlorinated congeners. The *Mysis* data were, for the most part, similar to the mussel data which showed rapid uptake between the start of the experiment and day 3, and then stable concentrations for 21 days. However, there was then an unexplained increase in *Mysis* PCB tissue concentrations between day 21 and day 24 when the experiment ended. A field study by Voie *et al.* (2002) found that transplanted blue mussels (*Mytilus edulis*) required almost two months to reach equilibrium when deployed in a Norwegian Fjord that had areas with both highly contaminated sediment and moderately contaminated sediment. Peven *et al.* (1996) also found that mussel PCB and total DDT tissue concentrations followed a similar pattern of bioaccumulation (rapid initial uptake within 48 hours and then a levelling off of tissue concentrations), when mussels were transplanted from a relatively clean environment to a PCB contaminated bay. However, in this case the mussels required up to 40 days to reach equilibrium.

The staggered deployment and retrieval of mussels in this study (i.e. long term mussels, group "A" and group "B"), provided a better understanding of the patterns of PCB bioaccumulation than the study design in 1997 (Richman 1999). The results from the 1997 study suggested that 21 days may be insufficient to assess maximum PCB accumulation. However, it was not known if mussel tissue concentrations increased over time due to a change in water quality or due to a delay in reaching steady state. However, the results from Two Mile Creek in 2000 suggested that the 21 day survey was sufficient to provide a good indication of the contamination of the area in which the mussels were deployed provided there were no changes in exposure. In addition to physiological changes that may occur and have not been accounted for in this study, the environment is in a constant state of flux due to external forces such as storm events or fluctuations in contaminant loadings from local industries. The data suggest that the mussel tissue concentrations will respond to this dynamic environment. The disadvantage of a short term monitoring program using introduced organisms is that significant contaminant inputs can be missed if they occur outside the designated period of biomonitoring.

Chlorotoluene, Octachlorostyrene and pp'-DDE

Mussels accumulated trace concentrations of pp'-DDE within 24 hours of deployment. Concentrations remained low throughout the survey and there were no changes in tissue concentrations over time. Concentrations ranged from below the detection limit to 7 ng/g (Table 8). The tissue concentrations of pp'-DDE did not follow the pattern of PCB bioaccumulation (i.e. an increase in tissue concentrations on day 63), which suggests two different sources for these contaminants. The pp'-DDE tissue concentrations likely reflect historical background contamination which is representative of the whole watershed while the PCB data suggest a point or non-point source.

The only other parameters consistently detected in mussel tissue were octachlorostyrene and 2,4,5-trichlorotoluene. These compounds were detected in mussels retrieved on or after October 3, 2000. This corresponded to 84 days of exposure for the "long term" experimental mussels and 63 and 42 days of exposure for the staggered deployments. Exposure to these parameters likely increased between September 12 and October 3, 2000. Uptake was clearly not linked to the length of deployment since previous long term deployment surveys showed that caged mussels have the ability to accumulate 2,4,5-trichlorotoluene within 24 hours of deployment (Richman 1997), and all the deployed mussels (long term and group A and B), accumulated the contaminant over the same time. As well, tissue concentrations were similar in all mussels regardless of length of exposure and remained the same for the remaining 21 days (Table 8).

SUMMARY OF SIGNIFICANT FINDINGS AND RECOMMENDATIONS

1) DDE was detected at most stations in mussels on both sides of the river at low concentrations indicating that historic contamination with this compound is widespread. Organochlorine pesticides were detected sporadically at several stations on the U.S. side of the river at concentrations previously detected in other Niagara River mussel surveys. The consistent detection of -BHC in mussels deployed in Gill creek when combined with the NYSDEC YOY fish data suggest that potential sources to the creek should be investigated.

2) Trace concentrations of PCBs and chlorinated benzene compounds were detected at almost all stations on the American side of the river. The most frequently detected chlorinated benzenes were: hexachlorobenzene, pentachlorobenzene and 1,2,3,4-tetrachlorobenzene. Concentrations of these parameters were typical of those observed in previous mussel monitoring surveys. The highest concentrations were present in mussels deployed at Bloody Run Creek and Sewer 003 (Occidental Chemical Corporation , Buffalo Avenue plant). Monitoring of these stations should continue in future biomonitoring surveys.

3) High concentrations of total and congener specific PCBs were detected in mussels deployed downstream of a sewer associated with the Occidental Chemical Corporation Buffalo Avenue plant. The source of PCBs to this area should be investigated by responsible parties.

4) High concentrations of dioxins and furans continue to be detected in mussels and sediment from the Pettit Flume inlet cove. The source of the dioxins and furans remains unclear given the recent extensive remedial activities at this site. The TEQ for the Pettit Flume cove sediment was 30,250 pg/g and for mussels 77 pg/g. Future mussel surveys should include additional monitoring of this site and include dioxin/furan analysis of mussels and sediment at the upstream reference site and a site located in the Little Niagara River. The source of the re-contamination of this cove requires further investigation, particularly since the sediment in the cove was removed only months prior to the mussel survey.

5) Dioxin and furan concentrations in sediment from the Niagara River shoreline at the Bloody Run Creek site were considerably lower in 2000 than previous surveys. However, since the shoreline has not been remediated the data likely represent the spatial variability in contamination and do not imply a trend through time. Concentrations of dioxins and furans in mussels and sediment still indicate that this site is contaminated with these parameters (TEQ in sediment 3,732 pg/g; mussels 23 pg/g). Continued monitoring of this site is still recommended for future surveys.

6) Sediment collected from Two Mile Creek and from the station in Gill Creek upstream of the creek mouth were contaminated with dioxins and furans. Given the recent remediation (1998) of sediment in Gill Creek this data suggests that there is a source that requires further investigation.

7) Mussels deployed for up to 105 days showed a rapid initial uptake of PCBs within 48 hours and then a slow increase and levelling off of tissue concentrations with time between day 7 and 42 days of exposure (range: 60-100 ng/g).This was followed by an increase in tissue concentrations in mussels retrieved after 63, 84 and 105 days of deployment when a new steady state appeared to have been reached. This may have been a response to increased PCB loadings to the system. A similar pattern was observed in mussels which were deployed at staggered intervals confirming that a 21 day deployment is sufficient time to provide a good indication of the contamination of the area in which they were exposed provided there were no changes in exposure. Octachlorosyrene and 2,4,5-trichlorotoluene were also bioavailable in Two Mile Creek.

Table 8: Summary of organic contaminant concentrations (ng/g wet wt.) in caged mussels deployed in Two Mile Creek for up to 105 days, 2000

Length of Exposure	Retrieval Date	a-Chlordane		pp-DDE		pp-DDT		Hexachloro-butadiene		1,2,4,5-tetrachloro-benzene		Hexachloro-benzene		Octachloro-styrene		2,3,6-trichloro-toluene		2,4,5-trichloro-toluen3		2,6-dichlorobenzyl chlorida	
24 hr	12-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	12-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	12-Jul-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
48 hr	13-Jul-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	13-Jul-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	13-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
70 hr	14-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	14-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	14-Jul-00	2	<=W	4	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
7 days	18-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	18-Jul-00	2	<=W	2	<T	5	<=W	2	<T	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	18-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
14 days	25-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	2	<T	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	25-Jul-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	25-Jul-00	2	<=W	4	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
21 days	01-Aug-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	01-Aug-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	01-Aug-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
42 days	22-Aug-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	22-Aug-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	22-Aug-00	2	<=W	2	<T	10	<T	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
21 days(A)*	22-Aug-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	22-Aug-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	22-Aug-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
63 days	12-Sep-00	2	<=W	2	<T	10	<T	1	<=W	1	<=W	3	<T	1	<=W	1	<=W	1	<=W	1	<=W
	12-Sep-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	2	<T	1	<=W	1	<=W	1	<=W	1	<=W
	12-Sep-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
42 days(A)	12-Sep-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	3	<T	1	<=W	1	<=W	1	<=W	1	<=W
	12-Sep-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	2	<T	1	<=W	1	<=W	1	<=W	1	<=W
	12-Sep-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
21 days(B)	12-Sep-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	12-Sep-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
	12-Sep-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
84 days	03-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	4	<T	1	<=W	17		1	<=W
	03-Oct-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	1	<=W	10		1	<=W
	03-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	2	<T	9	<T	11		1	<=W
63 days(A)	03-Oct-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	4	<T	8	<T	10		1	<=W
	03-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	3	<T	1	<=W	8	<T	1	<=W
	03-Oct-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	4	<T	5	<T	5	<T	1	<=W
42 days(B)	03-Oct-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	2	<T	1	<=W	7	<T	1	<=W
	03-Oct-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	4	<T	1	<=W	12		1	<=W
	03-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	3	<T	1	<=W	10		1	<=W
105 days	24-Oct-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	4	<T	1	<=W	10		1	<=W
	24-Oct-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	4	<T	1	<=W	8	<T	1	<=W
	24-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	3	<T	1	<=W	8	<T	1	<=W
84 days(A)	24-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	3	<T	17		18		5	<T
	24-Oct-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	2	<T	1	<=W	19		1	<=W
	24-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	3	<T	11		13		4	<T
63 days(B)	24-Oct-00	2	<=W	2	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	5	<T	5	<T	5	<T
	24-Oct-00	2	<=W	1	<=W	5	<=W	1	<=W	1	<=W	1	<=W	2	<T	10		1	<=W	1	<=W
	24-Oct-00	2	<=W	3	<T	5	<=W	1	<=W	1	<=W	1	<=W	1	<=W	7	<T	7	<T	3	<T

<W no measurable response
<T measurable trace amount, interpret with caution
21 days(A)* = 21 days of exposure for Group A mussels

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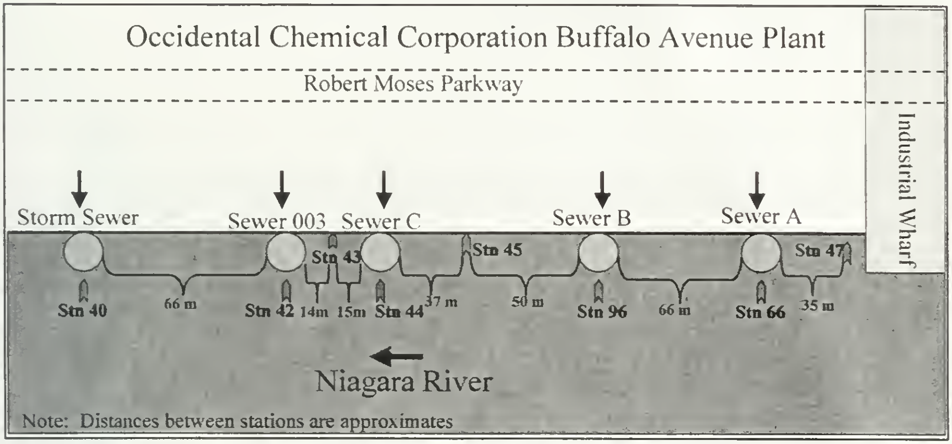
APPENDICES

Appendix A: Location of mussel sampling stations at outfalls associated with the Occidental Chemical Corporation, Buffalo Avenue Plant.



Note: Distances between stations are approximates

Appendix B: Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		Station #	Field #	Date	Time	Latitude	Longitude	Percent lipid	RQ1	Aldrin	RQ1	a-BHC (hexachlorocyclohexane)	RQ2	b-BHC (hexachlorocyclohexane)	RQ3	g-BHC (hexachlorocyclohexane)	RQ4
						degree-min-sec		LIPIDS		P1ALDR		P1BHCA		P1BHCB		P1BHCG	
								%		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
NOTL		00001100020009	GL001330	01-Aug-00	1200	43-75-13.6	79-03-36.6	0.1		1	<=W	1	<=W	1	<=W	1	<=W
NOTL		00001100020009	GL001331	01-Aug-00	1200			0.63		1	<=W	1	<=W	1	<=W	1	<=W
NOTL		00001100020009	GL001332	01-Aug-00	1200			0.3		1	<=W	1	<=W	1	<=W	1	<=W
Two Mile Creek		00000500020197	GL001333	01-Aug-00	1345	43-00-38.14	78-54-24.62	0.2		1	<=W	1	<=W	1	<=W	1	<=W
Two Mile Creek		00000500020197	GL001334	01-Aug-00	1345			0.35		1	<=W	1	<=W	1	<=W	1	<=W
Two Mile Creek		00000500020197	GL001335	01-Aug-00	1345			0.67		1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		00000500020031	GL001336	01-Aug-00	1430	43-02-52.4	78-53-32.2	0.34		1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		00000500020031	GL001337	01-Aug-00	1430			0.31		1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		00000500020031	GL001338	01-Aug-00	1430			0.1	<MDL	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		00000500020199	GL001339	01-Aug-00	1500	43-03-25.91	78-54-18.00	0.22		1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		00000500020199	GL001340	01-Aug-00	1500			0.53		1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		00000500020199	GL001341	01-Aug-00	1500			0.25		1	<=W	1	<=W	1	<=W	1	<=W
102nd Street (upstream)		00000500020093	GL001342	01-Aug-00	1515	43-02-52.35	78-53-32.18	0.35		1	<=W	1	<=W	1	<=W	1	<=W
102nd Street (upstream)		00000500020093	GL001343	01-Aug-00	1515			0.11		1	<=W	1	<=W	1	<=W	1	<=W
102nd Street (upstream)		00000500020093	GL001344	01-Aug-00	1515			0.42		1	<=W	1	<=W	1	<=W	1	<=W
102nd Street		00000500020022	GL001345	01-Aug-00	1545	43-04-23.98	78-57-05.44	0.52		1	<=W	1	<=W	1	<=W	1	<=W
102nd Street		00000500020022	GL001346	01-Aug-00	1545			0.26		1	<=W	1	<=W	1	<=W	1	<=W
102nd Street		00000500020022	GL001347	01-Aug-00	1545			0.57		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		00000500020185	GL001348	02-Aug-00	830	43-02-01.59	78-53-07.37	0.78		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		00000500020185	GL001349	02-Aug-00	830			0.35		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		00000500020185	GL001350	02-Aug-00	830			0.82		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		00000500020187	GL001351	02-Aug-00	920	43-02-03.63	78-53-11.25	0.81		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		00000500020187	GL001352	02-Aug-00	920			0.38		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		00000500020187	GL001353	02-Aug-00	920			0.17		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (site B)		00000500020188	GL001354	02-Aug-00	1040	43-02-04.41	78-53-08.10	0.39		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (site B)		00000500020188	GL001355	02-Aug-00	1040			0.53		1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (site B)		00000500020188	GL001356	02-Aug-00	1040			0.12		1	<=W	1	<=W	1	<=W	1	<=W
Buffalo River		00000500020220	GL001357	02-Aug-00	1140	42-51-58.0	78-52-08.0	0.84		1	<=W	1	<=W	1	<=W	1	<=W
Buffalo River		00000500020220	GL001358	02-Aug-00	1140			0.43		1	<=W	1	<=W	1	<=W	1	<=W
Buffalo River		00000500020220	GL001359	02-Aug-00	1140			0.51		1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		00000500020003	GL001363	02-Aug-00	1230	43-00-23.9	78-55-05.5	0.32		1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		00000500020003	GL001364	02-Aug-00	1230			0.45		1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		00000500020003	GL001365	02-Aug-00	1230			0.46		1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		00000500020092	GL001366	02-Aug-00	1300	43-00-30.93	78-54-47.90	0.2		1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		00000500020092	GL001367	02-Aug-00	1300			0.39		1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		00000500020092	GL001368	02-Aug-00	1300			0.54		1	<=W	1	<=W	1	<=W	1	<=W
Gill Creek (upstream)		00000500150022	GL001369	02-Aug-00	1520	43-05-04.19	79-01-25.10	0.33		1	<=W	26		7	<T	3	<T
Gill Creek (upstream)		00000500150022	GL001370	02-Aug-00	1520			0.25		1	<=W	16		5	<T	2	<T
Gill Creek (upstream)		00000500150022	GL001371	02-Aug-00	1520			0.35		1	<=W	19		5	<T	2	<T

< W:no measurable response
< T: measurable trace amount
P40.PCB resembled mixture of aroclor 1254 and 1260

Appendix B: Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		Station #	Field #	Date	Time	Latitude	Longitude	Percent lipid	RQ1	Aldrin	RQ1	a-BHC (hexachlorocyclohexane)	RQ2	b-BHC (hexachlorocyclohexane)	RQ3	g-BHC (hexachlorocyclohexane)	RQ4
						degree-min-sec		LIPIOS		P1ALDR		P1BHCA		P1BHCB		P1BHCG	
								%		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
Gill Creek (mouth)		00000500020037	GL001372	02-Aug-00	1550	43-04-41.71	79-01-34.23	0.34		1	<=W	2	<T	1	<=W	1	<=W
Gill Creek (mouth)		00000500020037	GL001373	02-Aug-00	1550			0.44		1	<=W	2	<T	1	<=W	1	<=W
Gill Creek (mouth)		00000500020037	GL001374	02-Aug-00	1550			0.36		1	<=W	2	<T	1	<=W	1	<=W
Bloody Run Creek (upstream)		00001100020018	GL001375	03-Aug-00	845	43-08-13.87	79-02-37.05	0.31		1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek (upstream)		00001100020018	GL001376	03-Aug-00	845			0.45		1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek (upstream)		00001100020018	GL001377	03-Aug-00	845			0.48		1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek		00001100020017	GL001378	03-Aug-00	900	43-08-18.1	79-02-34.0	0.4		1	<=W	1	<=W	8	<T	1	<=W
Bloody Run Creek		00001100020017	GL001379	03-Aug-00	900			0.24		1	<=W	1	<=W	5	<T	1	<=W
Bloody Run Creek		00001100020017	GL001380	03-Aug-00	900			0.12		1	<=W	1	<=W	6	<T	1	<=W
Bloody Run Creek (downstream)		00001100020025	GL001381	03-Aug-00	910	43-08-17.8	79-02-33.8	0.1		1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek (downstream)		00001100020025	GL001382	03-Aug-00	910			0.27		1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek (downstream)		00001100020025	GL001383	03-Aug-00	910			0.37		1	<=W	1	<=W	1	<=W	1	<=W
Lyons Creek		00000500150020	GL001384	03-Aug-00	1040	42-58-29.17	79-13-12.51	0.45		1	<=W	1	<=W	1	<=W	1	<=W
Lyons Creek		00000500150020	GL001385	03-Aug-00	1040			0.13		1	<=W	1	<=W	1	<=W	1	<=W
Lyons Creek		00000500150020	GL001386	03-Aug-00	1040			0.48		1	<=W	1	<=W	1	<=W	1	<=W
Fort Erie		00000500020203	GL001387	03-Aug-00	1210	42-55-41.12	78-54-47.86	0.23		1	<=W	1	<=W	1	<=W	1	<=W
Fort Erie		00000500020203	GL001388	03-Aug-00	1210			0.39		1	<=W	1	<=W	1	<=W	1	<=W
Fort Erie		00000500020203	GL001389	03-Aug-00	1210			0.19		1	<=W	1	<=W	1	<=W	1	<=W
Boyers Creek		00000500150005	GL001390	03-Aug-00	1245	43-00-06.75	79-01-48.72	0.48		1	<=W	1	<=W	1	<=W	1	<=W
Boyers Creek		00000500150005	GL001391	03-Aug-00	1245			0.28		1	<=W	1	<=W	1	<=W	1	<=W
Boyers Creek		00000500150005	GL001392	03-Aug-00	1245			0.21		1	<=W	1	<=W	1	<=W	1	<=W
Chippewa Channel		00000500020051	GL001393	03-Aug-00	1310	43-02-58.5	79-01-14.4	0.29		1	<=W	1	<=W	1	<=W	1	<=W
Chippewa Channel		00000500020051	GL001394	03-Aug-00	1310			0.22		1	<=W	1	<=W	1	<=W	1	<=W
Chippewa Channel		00000500020051	GL001419	03-Aug-00	1310			0.3		1	<=W	1	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		00000500020047	GL001396	04-Aug-00	842	43-04-27.78	79-00-19.48	0.42		1	<=W	1	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		00000500020047	GL001397	04-Aug-00	842			0.5		1	<=W	1	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		00000500020047	GL001420	04-Aug-00	842			0.54		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer A		00000500020046	GL001398	04-Aug-00	852	43-04-27.79	79-00-19.46	0.63		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer A		00000500020046	GL001399	04-Aug-00	852			0.55		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer A		00000500020046	GL001400	04-Aug-00	852			0.45		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer B		00000500020094	GL001401	04-Aug-00	902	43-04-28.45	79-00-21.71	0.59		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer B		00000500020094	GL001402	04-Aug-00	902			0.52		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer B		00000500020094	GL001403	04-Aug-00	902			0.45		1	<=W	1	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		00000500020045	GL001404	04-Aug-00	911	43-04-29.01	79-00-23.71	0.76		1	<=W	1	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		00000500020045	GL001405	04-Aug-00	911			0.25		1	<=W	1	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		00000500020045	GL001406	04-Aug-00	911			0.24		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer C		00000500020044	GL001407	04-Aug-00	928	43-04-29.87	79-00-25.28	0.23		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer C		00000500020044	GL001408	04-Aug-00	928			0.24		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer C		00000500020044	GL001409	04-Aug-00	928			0.39		1	<=W	1	<=W	1	<=W	1	<=W
Downstream Sewer C		00000500020043	GL001410	04-Aug-00	940	43-04-29.79	79-00-25.87	0.45		1	<=W	1	<=W	1	<=W	1	<=W
Downstream Sewer C		00000500020043	GL001411	04-Aug-00	940			0.29		1	<=W	1	<=W	1	<=W	1	<=W
Downstream Sewer C		00000500020043	GL001412	04-Aug-00	940			0.21		1	<=W	1	<=W	8	<T	1	<=W
Sewer 003		00000500020042	GL001413	04-Aug-00	948	43-04-30.21	79-00-28.25	0.43		1	<=W	1	<=W	1	<=W	1	<=W
Sewer 003		00000500020042	GL001414	04-Aug-00	948			0.38		1	<=W	1	<=W	1	<=W	1	<=W
Sewer 003		00000500020042	GL001415	04-Aug-00	948			0.32		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer (S&N area)		00000500020040	GL001416	04-Aug-00	1003	43-04-31.10	79-00-28.83	0.35		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer (S&N area)		00000500020040	GL001417	04-Aug-00	1003			0.2		1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer (S&N area)		00000500020040	GL001418	04-Aug-00	1003			0.57		1	<=W	1	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		00000500150032	GL002906	22-Aug-00	1200	43-01-1.80	78-52-15.65	0.56		1	<=W	1	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		00000500150032	GL002907	22-Aug-00	1200			0.52		1	<=W	1	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		00000500150032	GL002908	22-Aug-00	1200			0.2		1	<=W	1	<=W	1	<=W	1	<=W

< W:no measurable response
< T. measurable trace amount
P40 PCB resembled mixture of aroclor 1254 and 1260

Appendix B: Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		a-Chlordane	RQ5	g-Chlordane	RQ6	Heptachlor	RQ7	Mirex	RQ8	op-DDT	RQ9	PCB, total	RQ10	Photomirex	R11	pp-DDD	RQ12	pp-DDE	RQ13	pp-DDT	RQ14	Toxephene	RQ15	Hexachlorobutadiene	RQ18
		P1CHLA		P1CHLG		P1HEPT		P1MIRX		P1OPDT		P1PCBT		P1PMIR		P1PPDD		P1PPDE		P1PPDT		P1TOX		X1HCBD	
		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
NOTL		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
NOTL		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
NOTL		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Two Mile Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Two Mile Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Two Mile Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Gratwick/Riverside Park (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Gratwick/Riverside Park (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Gratwick/Riverside Park (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Gratwick/Riverside Park		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Gratwick/Riverside Park		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Gratwick/Riverside Park		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
102nd Street (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
102nd Street (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
102nd Street (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
102nd Street		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
102nd Street		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
102nd Street		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	4	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (downstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (downstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	4	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (downstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (site B)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Pettit Flume (site B)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Pettit Flume (site B)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	2	<T
Buffalo River		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
Buffalo River		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Buffalo River		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	4	<T	5	<=W	200	<=W	1	<=W
Tonawanda Channel (upstream-92)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
Tonawanda Channel (upstream-92)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	4	<T	5	<=W	200	<=W	1	<=W
Tonawanda Channel (upstream-92)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Tonawanda Channel (upstream-197)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Tonawanda Channel (upstream-197)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Tonawanda Channel (upstream-197)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
Gill Creek (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Gill Creek (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	6	<T	5	<=W	200	<=W	1	<=W
Gill Creek (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W

< W no measurable response
< T measurable trace amount
P40 PCB resembled mixture of aroclor 1254 and 1260

Appendix B. Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		e-Chlordane	RQ5	g-Chlordane	RQ6	Heptachlor	RQ7	Mirex	RQ8	op-DDT	RQ9	PCB, total	RQ10	Photomirex	R11	pp-DDD	RQ12	pp-DDE	RQ13	pp-DDT	RQ14	Toxephene	RQ15	Hexachlorobutediene	RQ16
		P1CHLA		P1CHLG		P1HEPT		P1MIRX		P1OPDT		P1PCBT		P1PMIR		P1PPDD		P1PPDE		P1PPDT		P1TOX		X1HCBD	
		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
Gill Creek (mouth)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	17	
Gill Creek (mouth)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	21	
Gill Creek (mouth)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	18	
Bloody Run Creek (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Bloody Run Creek (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Bloody Run Creek (upstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Bloody Run Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	6	<T
Bloody Run Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	10	
Bloody Run Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	9	<T
Bloody Run Creek (downstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Bloody Run Creek (downstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Bloody Run Creek (downstream)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Lyons Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Lyons Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Lyons Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	3	<T	5	<=W	200	<=W	1	<=W
Fort Erie		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	4	<T	5	<=W	200	<=W	1	<=W
Fort Erie		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	1	<=W
Fort Erie		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Boyers Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Boyers Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Boyers Creek		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Chippawa Channel		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Chippawa Channel		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Chippawa Channel		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	20	<=W	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Upstream Storm Sewer A		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Upstream Storm Sewer A		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Upstream Storm Sewer A		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	52		5	<=W	200	<=W	1	<=W
Storm Sewer A		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer A		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer A		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer B		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer B		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer B		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Between Sewer B and Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Between Sewer B and Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Between Sewer B and Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	80	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Storm Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	1	<=W
Downstream Sewer C		2	<=W	4	<T	1	<=W	5	<=W	5	<=W	340	P40	4	<=W	5	<=W	6	<T	5	<=W	200	<=W	4	<T
Downstream Sewer C		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	260	P40	4	<=W	5	<=W	5	<T	5	<=W	200	<=W	4	<T
Downstream Sewer C		2	<=W	6	<T	1	<=W	5	<=W	5	<=W	240	P40	4	<=W	5	<=W	6	<T	5	<=W	200	<=W	6	<T
Sewer 003		2	<=W	4	<T	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	42	
Sewer 003		2	<=W	4	<T	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	52	
Sewer 003		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	21		5	<=W	200	<=W	44	
Storm Sewer (S&N area)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	100	P40	4	<=W	5	<=W	2	<T	5	<=W	200	<=W	6	<T
Storm Sewer (S&N area)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	5	<T	5	<=W	200	<=W	4	<T
Storm Sewer (S&N area)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	1	<=W	5	<=W	200	<=W	6	<T
Ellicott Creek (Columbus Mckinnon)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	40	P40	4	<=W	5	<=W	7	<T	5	<=W	200	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		4	<T	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	5	<T	5	<=W	200	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		2	<=W	2	<=W	1	<=W	5	<=W	5	<=W	60	P40	4	<=W	5	<=W	5	<T	5	<=W	200	<=W	1	<=W

< W no measurable response
< T: measurable trace amount
P40 PCB resembled mixture of aroclor 1254 and 1260

Appendix B: Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		1,2,3-trichlorobenzene	RQ17	1,2,3,4-tetrachlorobenzene	RQ18	1,2,3,5-tetrachlorobenzene	RQ19	1,2,4-trichlorobenzene	RQ20	1,2,4,5-tetrachlorobenzene	RQ21	1,3,5-trichlorobenzene	RQ22	Hexachlorobenzene	RQ23	Hexachloroethane	RQ24
		X2123		X21234		X21235		X2124		X21245		X2135		X2HCB		X2HCE	
		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
NOTL		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
NOTL		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
NOTL		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Two Mile Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Two Mile Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Two Mile Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
102nd Street (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
102nd Street (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
102nd Street (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
102nd Street		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
102nd Street		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
102nd Street		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (upstreem)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (site B)		2	<=W	2	<T	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (site B)		2	<=W	1	<=W	2	<T	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Pettit Flume (site B)		2	<=W	6	<T	3	<T	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Buffalo River		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Buffalo River		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Buffalo River		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gill Creek (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gill Creek (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gill Creek (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W

< W:no measurable response
< T: measurable trace amount
P40:PCB resembled mixture of aroclor 1254 and 1260

Appendix B. Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		1,2,3-trichlorobenzene	RQ17	1,2,3,4-tetrachlorobenzene	RQ18	1 2 3,5-tetrachlorobenzene	RQ19	1,2,4-trichlorobenzene	RQ20	1,2,4,5-tetrachlorobenzene	RQ21	1,3,5-trichlorobenzene	RQ22	Hexachlorobenzene	RQ23	Hexachloroethane	RQ24
		X2123		X21234		X21235		X2124		X21245		X2135		X2HCB		X2HCE	
		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
Gill Creek (mouth)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Gill Creek (mouth)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	4	<T	1	<=W	1	<=W
Gill Creek (mouth)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	4	<T	1	<=W	1	<=W
Bloody Run Creek (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Bloody Run Creek (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Bloody Run Creek (upstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Bloody Run Creek		2	<=W	7	<T	7	<T	2	<=W	3	<T	2	<=W	19		1	<=W
Bloody Run Creek		2	<=W	8	<T	7	<T	2	<=W	3	<T	4	<T	20		1	<=W
Bloody Run Creek		2	<=W	7	<T	7	<T	2	<=W	4	<T	2	<=W	13		1	<=W
Bloody Run Creek (downstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	3	<T	1	<=W
Bloody Run Creek (downstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	8	<T	1	<=W
Bloody Run Creek (downstream)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	8	<T	1	<=W
Lyons Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Lyons Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Lyons Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Fort Erie		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Fort Erie		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Fort Erie		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Boyers Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Boyers Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Boyers Creek		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Chippawa Channel		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Chippawa Channel		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Chippawa Channel		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	2	<T	1	<=W
Storm Sewer A		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Storm Sewer A		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	5	<T	1	<=W
Storm Sewer A		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Storm Sewer B		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Storm Sewer B		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Storm Sewer B		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	2	<T	1	<=W
Between Sewer B and Sewer C		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	2	<T	1	<=W
Between Sewer B and Sewer C		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Storm Sewer C		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	2	<T	1	<=W
Storm Sewer C		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Storm Sewer C		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	2	<T	1	<=W
Downstream Sewer C		2	<=W	3	<T	1	<=W	2	<=W	1	<=W	2	<=W	5	<T	1	<=W
Downstream Sewer C		2	<=W	2	<T	1	<=W	2	<=W	3	<T	2	<=W	5	<T	1	<=W
Downstream Sewer C		2	<=W	8	<T	1	<=W	2	<=W	3	<T	2	<=W	13		1	<=W
Sewer 003		2	<=W	14		1	<=W	2	<=W	3	<T	4	<T	23		1	<=W
Sewer 003		2	<=W	11		4	<T	2	<=W	1	<=W	2	<=W	24		1	<=W
Sewer 003		2	<=W	12		1	<=W	2	<=W	3	<T	2	<=W	1	<=W	1	<=W
Storm Sewer (S&N area)		2	<=W	3	<T	1	<=W	2	<=W	1	<=W	2	<=W	8	<T	1	<=W
Storm Sewer (S&N area)		2	<=W	2	<T	1	<=W	2	<=W	1	<=W	2	<=W	5	<T	1	<=W
Storm Sewer (S&N area)		2	<=W	4	<T	1	<=W	2	<=W	1	<=W	2	<=W	9	<T	1	<=W
Ellicott Creek (Columbus Mckinnon)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		2	<=W	1	<=W	1	<=W	2	<=W	1	<=W	2	<=W	1	<=W	1	<=W

< W no measurable response
< T: measurable trace amount
P40 PCB resembled mixture of aroclor 1254 and 1260

Appendix B: Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		Octachlorostyrene	RQ25	Pentachlorobenzene	RQ26	2,3,6-trichlorotoluen	RQ27	2,4,5-trichlorotoluen	RQ28	2,6-dichlorobenzyl chloride	RQ29
		X2OCST		X2PNCB		X2T236		X2T245		X2T26A	
		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
NOTL		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
NOTL		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
NOTL		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Two Mile Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Two Mile Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Two Mile Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gratwick/Riverside Park		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
102nd Street (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
102nd Street (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
102nd Street (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
102nd Street		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
102nd Street		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
102nd Street		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (downstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Pettit Flume (site B)		1	<=W	4	<T	1	<=W	1	<=W	1	<=W
Pettit Flume (site B)		1	<=W	14		5	<T	1	<=W	1	<=W
Pettit Flume (site B)		1	<=W	11		1	<=W	1	<=W	1	<=W
Buffalo River		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Buffalo River		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Buffalo River		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		1	<=W	2	<T	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-92)		1	<=W	2	<T	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		1	<=W	2	<T	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		1	<=W	3	<T	1	<=W	1	<=W	1	<=W
Tonawanda Channel (upstream-197)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gill Creek (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gill Creek (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gill Creek (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W

< W no measurable response
< T: measurable trace amount
P40.PCB resembled mixture of aroclor 1254 and 1260

Appendix B· Concentration of contaminants (ng/g wet wt.) and percent lipid in caged mussels deployed in the Niagara River for 21 days, 2000

		Octachlorostyrene	RQ25	Pentachlorobenzene	RQ26	2,3,6-trichlorotoluen	RQ27	2,4,5-trichlorotoluen	RQ28	2,6-dichlorobenzyl chloride	RQ29
		X2OCST		X2PNCB		X2T236		X2T245		X2T26A	
		NG/G WET		NG/G WET		NG/G WET		NG/G WET		NG/G WET	
Gill Creek (mouth)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gill Creek (mouth)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Gill Creek (mouth)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek (upstream)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Bloody Run Creek (upstream)		1	<=W	1	<=W	2	<T	1	<=W	1	<=W
Bloody Run Creek (upstream)		1	<=W	3	<T	1	<=W	1	<=W	1	<=W
Bloody Run Creek		1	<=W	24		10		6	<T	3	<T
Bloody Run Creek		1	<=W	26		11		7	<T	2	<T
Bloody Run Creek		1	<=W	26		12		9	<T	4	<T
Bloody Run Creek (downstream)		1	<=W	5	<T	5	<T	1	<=W	1	<=W
Bloody Run Creek (downstream)		1	<=W	3	<T	6	<T	1	<=W	1	<=W
Bloody Run Creek (downstream)		1	<=W	3	<T	6	<T	1	<=W	1	<=W
Lyons Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Lyons Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Lyons Creek		1	<=W	3	<T	1	<=W	1	<=W	1	<=W
Fort Erie		1	<=W	3	<T	1	<=W	1	<=W	1	<=W
Fort Erie		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Fort Erie		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Boyers Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Boyers Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Boyers Creek		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Chippawa Channel		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Chippawa Channel		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Chippawa Channel		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Upstream Storm Sewer A		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer A		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer A		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer A		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer B		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer B		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer B		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Between Sewer B and Sewer C		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer C		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer C		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Storm Sewer C		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Downstream Sewer C		5	<T	4	<T	1	<=W	1	<=W	1	<=W
Downstream Sewer C		1	<=W	5	<T	1	<=W	1	<=W	1	<=W
Downstream Sewer C		1	<=W	18		1	<=W	1	<=W	1	<=W
Sewer 003		1	<=W	27		10		8	<T	1	<=W
Sewer 003		1	<=W	20		1	<=W	1	<=W	1	<=W
Sewer 003		1	<=W	22		9	<T	8	<T	1	<=W
Storm Sewer (S&N area)		1	<=W	5	<T	2	<T	1	<=W	1	<=W
Storm Sewer (S&N area)		1	<=W	3	<T	1	<=W	1	<=W	1	<=W
Storm Sewer (S&N area)		1	<=W	5	<T	2	<T	2	<T	1	<=W
Ellicott Creek (Columbus Mckinnon)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W
Ellicott Creek (Columbus Mckinnon)		1	<=W	1	<=W	1	<=W	1	<=W	1	<=W

< W no measurable response
< T measurable trace amount
P40 PCB resembled mixture of aroclor 1254 and 1260

Appendix C: Mussel tissue wet weight (g)

Mussels submitted for analysis of PCBs, organochlinated compounds and chlorinated benzenes							
Sampling Station	Station number	Mussel Tissue wet weight (g)					
Canadian Sites		Replicate 1	Replicate 2	Replicate 3	Mean	Standard Deviation (SD)	
Fort Erie at Robertson St.	(5-2)-203	6.5	7.4	7.3	7.1	0.5	
Boyers Creek	(5-15)-5	7.1	8.5	6.5	7.4	1.0	
Lyons Creek	(5-15)-20	6.4	6.6	6.7	6.6	0.2	
Chippawa Channel	(5-2)-51	7.3	6.8	7.9	7.3	0.6	
NOTL	(11-2)-9	7.0	6.6	8.3	7.3	0.9	
US Sites							
Buffalo River	(5-2)-220	7.8	8.7	8.7	8.4	0.5	
Tonawanda Channel	(5-2)-3	7.0	8.1	8.2	7.8	0.7	
Tonawanda Channel	(5-2)-92	7.0	7.2	7.4	7.2	0.2	
Two Mile Creek (mouth)	(5-2)-197	7.9	6.1	6.1	6.7	1.0	
Pettit Flume (upstream)	(5-2)-185	6.9	7.5	7.6	7.3	0.4	
Pettit Flume (site B)	(5-2)-186	6.6	7.3	8.5	7.5	1.0	
Pettit Flume (downstream)	(5-2)-187	7.9	7.5	7.7	7.7	0.2	
Gratwick/Riverside Park (upstream)	(5-2)-31	5.9	7.3	8.7	7.3	1.4	
Gratwick/Riverside Park	(5-2)-199	6.1	5.8	6.4	6.1	0.3	
102nd Street (upstream)	(5-2)-93	6.1	7.8	7.8	7.2	1.0	
102nd Street	(5-2)-22	9.9	8.9	6.1	8.3	2.0	
Upstream Sewer A	(5-2)-47	9.4	6.6	6.6	7.5	1.6	
Sewer A	(5-2)-46	6.4	8.2	6.5	7.0	1.0	
Sewer B	(5-2)-94	7.4	6.9	7.4	7.2	0.3	
Between Sewer B and Sewer C	(5-2)-45	7.3	6.6	6.9	6.9	0.4	
Sewer C	(5-2)-44	6.7	6.9	7.3	7.0	0.3	
Between Sewer C and Sewer 003	(5-2)-43	5.8	7.8	7.9	7.2	1.2	
Occidental Sewer 003	(5-2)-42	8.5	5.6	7.9	7.3	1.5	
Storm Sewer - S&N	(5-2)-40	8.1	7.9	8.5	8.2	0.3	
Gill Creek (upstream)	(5-15)-22	8.7	8.6	6.6	8.0	1.2	
Gill Creek	(5-2)-37	8.2	6.7	5.8	6.9	1.2	
Bloody Run Creek (upstream)	(11-2)-18	7.3	6.1	6.0	6.5	0.7	
Bloody Run Creek (mouth)	(11-2)-17	7.0	8.9	6.0	7.3	1.5	
Bloody Run Creek (downstream)	(11-2)-25	7.3	7.8	5.7	6.9	1.1	
Mussels submitted for analysis of dioxins, furans and dioxin-like PCBs						Mean	SD
Pettit Flume (upstream)		5.2	6.6	7.7	8.1	6.9	1.3
Pettit Flume (site B)		5.9	6.2	6.4	7.4	6.5	0.7
Pettit Flume (downstream)		7.9	6.4	5.8	5.8	6.5	1.0
Bloody Run Creek (upstream)		6.8	7.8	6.5	7.5	7.2	0.6
Bloody Run Creek (mouth)		7.0	7.4	7.8	6.1	7.1	0.7
Fort Erie at Robertson St.		5.8	7.5	5.1	5.9	6.1	1.0
Chippawa Channel		6.6	6.4	5.6	7.3	6.5	0.7
Balsam Lake Control Mussels						Overall mean	SD
		8.2	7.0	8.1	7.2	6.9	0.9
		6.0	7.4	7.0	5.9		
		6.2	7.1	6.1	7.1		
		6.1	7.2	6.2	7.6		
		6.5	7.4	6.1	6.3		
		9.2	5.3	6.2	7.6		
Long Term Experiment	Exposure Time				Mean	SD	
	21 days	7.9	6.1	6.1	6.7	1.0	
	42 days	8.5	8.0	5.8	7.4	1.4	
	21 days(a)	6.8	7.3	5.1	6.4	1.2	
	63 days	6.0	6.0	7.0	6.3	0.6	
	42 days(a)	6.8	7.0	5.9	6.6	0.6	
	21 days(b)	8.0	4.9	4.3	5.7	2.0	
	84 days	6.4	6.7	6.9	6.7	0.3	
	63 days(a)	7.3	8.0	7.3	7.5	0.4	
	42 days(b)	8.1	6.5	8.8	7.8	1.2	
	105 days	7.0	6.7	6.7	6.8	0.2	
	84 days(a)	5.6	8.5	5.8	6.6	1.6	
	63 days(b)	8.5	8.9	7.6	8.3	0.7	

Appendix D HydroLab data for selected stations in the Niagara River collected while caged mussels were retrieved 2000

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Stn 11-02-0009						
Niagara on the Lake						
Date (MMDDYY) 080100						
120515$	23.27	272	9.31	109.2	0.3	8.41
120530$	23.29	272	9.28	108.7	0.3	8.42
120545$	23.29	272	9.27	108.8	0.3	8.42
120600$	23.29	272	9.14	107.3	0.3	8.41
120615$	23.29	272	9.31	109.3	0.3	8.42
120630$	23.30	272	9.16	107.5	0.3	8.42
120645$	23.29	272	9.24	108.4	0.3	8.42
120700$	23.28	272	9.13	107.1	0.3	8.41
120715$	23.27	272	9.16	107.5	0.3	8.40
120730$	23.29	272	9.10	106.6	0.3	8.40
120745$	23.31	272	9.03	106.0	0.3	8.41
120800$	23.29	272	8.98	105.3	0.3	8.41
120815$	23.29	272	9.05	106.2	0.3	8.41
120830$	23.27	272	9.03	106.9	0.3	8.39
120845$	23.28	272	9.02	105.6	0.3	8.40
120900$	23.28	272	9.12	106.9	0.3	8.40
120915$	23.30	272	9.09	106.7	0.3	8.41
120930$	23.31	272	9.13	107.1	0.3	8.42
120945$	23.31	272	9.14	107.2	0.3	8.41
121000$	23.30	272	9.31	109.3	0.3	8.40
121015$	23.29	272	9.45	110.9	0.3	8.39
Stn 05-02-0197						
Two Mile Creek						
135615$	21.38	647	1.36	15.5	0.3	8.96
135630$	21.42	647	1.37	15.5	0.3	8.96
135645$	21.43	645	1.36	15.4	0.3	8.96
135700$	21.41	643	1.35	15.3	0.3	8.96
135715$	21.45	641	1.35	15.3	0.3	8.96
135730$	21.45	640	1.34	15.2	0.3	8.95
135745$	21.44	641	1.35	15.3	0.3	8.95
135800$	21.44	642	1.34	15.2	0.3	8.96
135815$	21.47	642	1.34	15.2	0.3	8.95
135830$	21.45	642	1.34	15.2	0.3	8.96
135845$	21.48	641	1.33	15.0	0.3	8.95
135900$	21.48	641	1.34	15.2	0.3	8.95
135915$	21.49	648	1.34	15.2	0.3	8.95
135930$	21.48	649	1.33	15.1	0.3	8.95
135945$	21.48	647	1.33	15.1	0.3	8.96
140000$	21.47	647	1.33	15.1	0.3	8.95
140015$	21.49	644	1.33	15.1	0.3	8.96
140030$	21.51	641	1.33	15.1	0.3	8.95
140045$	21.45	643	1.32	15.0	0.3	8.96
140100$	21.49	641	1.33	15.1	0.3	8.96
140115$	21.36	640	1.32	15.0	0.3	8.96
Stn 05-02-0031						
Gratwick/Riverside Park (upstream)						
142545$	23.71	283	8.51	100.7	0.2	8.21
142600$	23.72	283	8.33	98.5	0.2	8.22
142615$	23.72	283	8.19	96.8	0.2	8.23
142630$	23.72	283	8.16	96.5	0.2	8.23
142645$	23.71	283	8.22	97.2	0.2	8.23
142700$	23.72	283	8.33	98.5	0.2	8.25
142715$	23.72	283	8.24	97.5	0.2	8.25
142730$	23.72	283	8.27	97.8	0.2	8.24
142745$	23.72	283	8.27	97.6	0.2	8.24
142800$	23.72	283	8.25	97.6	0.2	8.24
142815$	23.72	283	8.30	98.1	0.2	8.24
142830$	23.72	283	8.41	99.5	0.2	8.24
142845$	23.71	283	8.10	95.8	0.2	8.24
142900$	23.71	283	8.08	95.5	0.2	8.24
142915$	23.71	283	8.08	95.6	0.2	8.24
142930$	23.71	283	8.06	95.3	0.2	8.24
Stn 05-02-0199						
Gratwick/Riverside Park						
145030$	24.96	293	9.69	117.3	0.2	8.50
145045$	24.94	293	9.75	118.0	0.2	8.50
145100$	24.98	293	9.71	117.5	0.1	8.51
145115$	24.99	293	9.70	117.5	0.2	8.51
145130$	24.97	293	9.63	116.7	0.2	8.52
145145$	24.96	293	9.76	118.2	0.2	8.52
145200$	24.97	293	9.68	117.2	0.2	8.52
145215$	24.95	293	9.77	118.3	0.1	8.52
145230$	24.94	293	9.77	118.2	0.1	8.52
145245$	24.95	293	9.65	116.7	0.2	8.52
145300$	24.95	293	9.55	115.6	0.2	8.52
145315$	24.96	293	9.56	115.7	0.2	8.52
145330$	24.93	293	9.63	116.5	0.1	8.51
145345$	24.94	293	9.66	116.9	0.2	8.51
145400$	24.94	293	9.65	116.8	0.2	8.51
145415$	24.94	293	9.65	116.8	0.1	8.51
145430$	24.98	293	9.48	114.8	0.2	8.51
145445$	25.01	293	9.51	115.3	0.2	8.51

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Stn 05-02-0093						
102nd Street (upstream)						
152030$	25 67	311	11 40	139 8	0 3	8 47
152045$	25 66	311	10 88	133 4	0 3	8 50
152100$	25 66	311	10 63	130.3	0 3	8 51
152115$	25 67	311	10 95	134 3	0 3	8 51
152130$	25 67	311	10 94	134 2	0 3	8 52
152145$	25 66	311	10 90	133 7	0 3	8 52
152200$	25 67	311	10 99	134 8	0 3	8 52
152215$	25 68	311	10 98	134 7	0 3	8 52
152230$	25 67	311	10 90	133 7	0 3	8 52
152245$	25 68	311	10 97	134 5	0 3	8 52
152300$	25 69	311	10 98	134 7	0 3	8 52
152315$	25 68	311	10 85	133 2	0 3	8 52
152330$	25 70	311	10 82	132 8	0 3	8 52
152345$	25 69	311	10 87	133 4	0 3	8 53
152400$	25 70	311	10 96	134 5	0 3	8 53
152415$	25 70	311	10 84	133 0	0 3	8 53
152430$	25 71	311	10 95	134 5	0 3	8 53
152445$	25 71	311	10 98	134 6	0 3	8 53
152500$	25 70	311	10 74	131 8	0 3	8 53
152515$	25 70	311	10 82	132 6	0 3	8 53
Stn 05-02-0022						
102nd Street						
154600$	25 98	313	9 74	120 2	0 1	8 46
154615$	25 96	313	9 83	121 2	0 1	8 47
154630$	25 98	313	9 90	122 2	0 1	8 47
154645$	25 98	313	9 90	122 1	0 1	8 47
154700$	25 98	313	9 86	121 7	0 1	8 47
154715$	25 99	313	9 96	122 9	0 1	8 47
154730$	25 98	313	9 92	122 4	0 1	8 47
154745$	25 98	313	9 91	122.3	0 1	8 47
154800$	25 96	313	9 84	121 4	0 1	8 47
154815$	25 99	313	9 86	121 7	0 1	8 47
154830$	25 99	313	9 92	122 5	0 1	8 47
154845$	25 99	313	9 85	121 5	0 1	8 47
154900$	26 00	313	9 96	122 9	0 1	8 47
154915$	25 99	313	9 92	122 4	0 1	8 47
154930$	25 99	313	9 84	121 4	0 1	8 47
154945$	26 00	313	9 81	121 0	0 1	8 47
155000$	26 00	313	9 90	122 2	0 1	8 47
155015$	26 01	313	9 82	121 2	0 1	8 47
155030$	26 00	313	9 89	122 1	0 1	8 47
155045$	26 00	313	9 94	122 6	0 1	8 47
Stn 05-02-0185						
Pettit Flume (upstream)						
Date (MMDDYY) 080200						
084400$	23 42	286	7 34	86 3	1 1	8 21
084415$	23 42	286	7 34	86 4	1 1	8 20
084430$	23 42	286	7 29	85 7	1 1	8 21
084445$	23 42	286	7 19	84 8	1 1	8 21
084500$	23 42	286	7 00	82 3	1 1	8 21
084515$	23 42	286	6 66	78 3	1 1	8 22
084530$	23 42	286	6 33	74 5	1 1	8 22
084545$	23 42	286	6 66	78 5	1 1	8 22
084600$	23 42	286	6 67	78 5	1 1	8 22
084615$	23 42	286	6 55	77 0	1 1	8 19
084630$	23 42	286	7 20	84 7	1 1	8 20
084645$	23 42	286	7 26	85 4	1 1	8 20
084700$	23 42	286	7.10	83 5	1 1	8 21
084715$	23 42	286	7 20	84 7	1 1	8 2[illegible]
084730$	23 42	286	6 92	81 4	1 1	8 21
084745$	23 42	286	6 89	81 0	1 1	8 20
084800$	23 42	286	7 25	85 2	1 1	8 19
084815$	23 41	286	7 42	87 3	1 1	8 19
084830$	23 42	286	7 32	86 1	1 1	8 20
084845$	23 42	286	7 02	82 5	1 1	8 20
Stn 05-02-0187						
Pettit Flume (downstream)						
092915$	23 41	288	6 50	76 4	1 0	8 12
092930$	23 40	288	6 54	76 9	1 0	8 12
092945$	23 41	288	6 40	75 3	1 0	8 11
093000$	23 41	288	6 28	73 9	1 0	8 11
093015$	23 41	288	6 40	75 2	1 0	8 11
093030$	23 41	288	6 62	77 8	1 0	8 10
093045$	23 41	288	6 66	78 3	1 0	8 10
093100$	23 41	288	6 72	79 0	1 0	8 11
093115$	23 41	288	6 44	75 8	1 0	8 11
093130$	23 41	288	6 76	79 5	1 0	8 11
093145$	23 41	287	6 77	79 6	1 0	8 11
093200$	23 41	287	6 92	81 4	1 0	8 11
093215$	23 41	287	6 94	81 6	1 0	8 11
093230$	23 41	287	6 95	81 7	1 0	8 10
093245$	23 41	287	7 00	82 4	1 0	8 11
093300$	23 41	287	6 89	81 0	1 0	8 10
093315$	23 41	287	6 79	79 9	1 0	8 11
093330$	23 41	287	6 84	80 4	1 0	8 11
093345$	23 40	287	6 84	80 5	1 0	8 10
093400$	23 41	287	6 93	81 5	1 0	8 10
093415$	23 41	287	6 83	80 3	1 0	8 10
093430$	23 41	287	6 87	80 8	1 0	8 11
093445$	23 41	287	6 87	80 8	1 0	8 11
093500$	23 41	287	6 83	80 3	1 0	8 11
093515$	23 41	287	6 81	80 1	1 0	8 10
093530$	23 41	287	6 77	79 6	1 0	8 11

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Pettit Flume (site B)						
Stn 05-02-0160						
103145$	22 65	244	7 21	83 8	0 1	7 67
103200$	22 89	266	7 05	81 7	0 1	7 70
103215$	22 27	287	7 07	81 3	0 1	7 68
103230$	22 32	253	7 47	86 0	0 1	7 67
103245$	22 22	301	7 42	85 4	0 1	7 62
103300$	22 24	301	7 37	84 7	0 1	7 63
103315$	22 11	315	7 37	84 8	0 1	7 62
103330$	22 06	314	7 33	84 0	0 1	7 62
103345$	22 04	322	7 38	84 5	0 1	7 60
103400$	21 90	354	7 60	86 8	0 1	7 60
103415$	22 03	342	7 38	84 8	0 1	7 60
103430$	22 09	334	7 29	83 8	0 1	7 60
103445$	22 10	332	7 10	81 4	0 1	7 60
103500$	21 99	354	7 09	81 2	0 1	7 60
103515$	22 23	330	8 95	79 9	0 1	7 62
103530$	22 08	353	7 07	81 0	0 1	7 81
103545$	21 90	379	7 12	81 4	0 1	7 81
103600$	22.20	341	7 02	80 7	0 1	7 62
103615$	21 47	448	7 26	82 3	0 1	7 57
103630$	21 41	451	7 27	82 4	0 1	7 58
103645$	21 53	439	7 30	82 9	0 1	7 57
Buffalo River						
Stn 05-02-0220						
113430$	23 12	333	5 95	69 7	0 0	7 48
113445$	23 12	333	5 72	66 9	0 0	7 45
113500$	23 11	333	5 65	66 1	0 0	7 43
113515$	23 12	333	5 69	66 5	0 0	7 42
113530$	23 13	333	5 72	66 9	0 1	7 42
113545$	23 13	333	5 65	66 1	0 1	7 41
113600$	23 13	333	5 60	65 6	0 1	7 40
113615$	23 13	333	5 56	65 1	0 1	7 40
113630$	23 12	333	5 58	65 3	0 0	7 41
113645$	23 12	333	5 62	65 7	0 0	7 41
113700$	23 12	334	5 81	65 7	0 1	7 42
113715$	23 11	334	5 66	66 3	0 1	7 41
113730$	23 12	334	5 65	66 1	0 0	7 41
113745$	23 12	333	5 57	65 1	0 0	7 41
113800$	23 12	333	5 53	64 7	0 0	7 40
113815$	23 13	333	5 48	64 2	0 0	7 39
113830$	23 13	333	5 46	63 8	0 0	7 39
113845$	23 13	333	5 46	63 8	0 0	7 39
113900$	23 14	333	5 37	62 8	0 0	7 39
113915$	23 13	333	5 36	62 8	0 0	7 39
113930$	23 14	333	5 44	63 7	0 0	7 38
Tonawanda Channel						
Stn 05-01-0003						
123845$	23 78	283	8 22	97 3	0 1	8 22
123900$	23 77	283	8 17	96 8	0 1	8 24
123915$	23 77	283	8 18	96 8	0 1	8 25
123930$	23 77	283	8 25	97 7	0 1	8 26
123945$	23 78	283	8 10	96 0	0 1	8 26
124000$	23 78	283	7 99	94 6	0 1	8 26
124015$	23 78	283	8 09	95 8	0 1	8 26
124030$	23 78	283	8 06	95 4	0 1	5 26
124045$	23 78	283	8 09	95 8	0 1	8 27
124100$	23 77	283	8 07	95 6	0 1	8.27
124115$	23 77	283	8 12	96 1	0 1	8 27
124130$	23 77	283	8 10	95 8	0 1	8.27
124145$	23 77	283	7 99	94 6	0 1	8 27
124200$	23 77	283	8 02	94 9	0 1	8 27
124215$	23 77	283	8 03	95 0	0 1	8 27
124230$	23 77	283	8 16	96 6	0 1	8 26
124245$	23 76	283	8 15	96 5	0 1	8.26
124300$	23 77	283	8 14	96 4	0 0	8 26
Tonawanda Channel						
Stn 05-01-0092						
130100$	23 91	285	8 07	95 8	0 1	8.26
130115$	23 91	284	7 97	94 6	0 2	8 28
130130$	23 90	284	7 98	94 7	0 1	8.28
130145$	23 89	284	8 02	95 2	0 1	8 28
130200$	23 88	285	8 07	95 8	0 2	8 29
130215$	23 89	285	8 04	95 4	0 2	8 28
130230$	23 90	285	8 06	95 7	0 2	8 29
130245$	23 90	285	8 03	96 3	0 2	8 29
130300$	23 90	284	7 98	94 7	0 2	8 29
130315$	23 89	285	7 99	94 8	-0 1	8 28

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Ellicott Creek						
Stn 05-02-0032						
141900$	22.54	762	7.69	89.1	0.2	7.77
141915$	22.50	761	7.09	82.1	0.1	7.76
141930$	22.49	762	6.61	78.8	0.1	7.76
141945$	22.49	762	6.72	77.8	0.1	7.76
142000$	22.49	761	6.42	74.3	0.1	7.75
142015$	22.49	758	6.76	78.2	0.1	7.75
142030$	22.49	759	6.43	74.5	0.1	7.75
142045$	22.51	760	6.40	74.2	0.1	7.75
142100$	22.50	759	6.33	73.3	0.1	7.75
142115$	22.51	759	6.23	72.2	0.1	7.75
142130$	22.51	760	6.57	76.1	0.1	7.75
142145$	22.51	759	6.58	76.2	0.1	7.74
142200$	22.52	758	6.49	75.1	0.1	7.74
142215$	22.51	759	6.45	74.7	0.1	7.74
142230$	22.50	758	6.41	74.3	0.1	7.75
142245$	22.51	757	6.46	74.8	0.1	7.75
142300$	22.49	755	6.59	76.3	0.1	7.75
142315$	22.51	756	6.36	73.6	0.1	7.75
142330$	22.50	758	6.40	74.1	0.1	7.75
142345$	22.50	754	6.71	77.7	0.1	7.75
142400$	22.49	753	6.53	75.5	0.1	7.75
142415$	22.50	754	6.59	76.3	0.1	7.75
142430$	22.49	754	6.55	75.8	0.1	7.75
142445$	22.50	754	6.46	74.8	0.1	7.75
142500$	22.50	753	6.69	77.4	0.1	7.75
142515$	22.50	752	6.48	75.0	0.1	7.74
142530$	22.51	752	6.50	75.2	0.1	7.75
142545$	22.48	751	6.34	73.3	0.1	7.75
142600$	22.48	754	6.30	72.9	0.1	7.75
142615$	22.46	749	6.28	72.6	0.1	7.74
Gill Creek						
Stn 05-15-0022						
151500$	26.57	284.3	9.52	118.7	0.1	8.41
151515$	26.83	526	8.82	110.6	0.0	8.42
151530$	26.61	526	7.90	99.0	0.0	8.41
151545$	26.81	527	7.78	97.3	0.0	8.40
151600$	26.82	526	8.04	100.7	0.0	8.41
151615$	26.83	525	7.73	96.9	0.0	8.40
151630$	26.67	526	7.60	95.3	0.0	8.41
151645$	26.89	525	7.32	91.9	0.0	8.44
151700$	26.89	525	7.46	93.8	0.0	8.43
151715$	26.90	525	7.74	97.1	0.0	8.43
151730$	26.84	526	8.01	100.5	0.0	8.42
151745$	26.84	526	7.93	99.4	0.0	8.42
Bloody Run Creek (upstream)						
Stn 11-02-0018						
Date (MMDDYY) 080300						
084215$	22.95	274	8.86	103.3	0.2	8.32
084230$	22.94	274	8.84	103.0	0.2	8.33
084245$	22.94	274	8.73	101.7	0.2	8.32
084300$	22.95	274	8.79	102.5	0.2	8.31
084315$	22.95	274	9.03	105.3	0.2	8.31
084330$	22.95	274	9.08	105.8	0.3	8.31
084345$	22.95	273	8.86	103.3	0.3	8.31
084400$	22.95	274	8.87	103.4	0.3	8.30
084415$	22.94	275	8.93	104.2	0.3	8.29
084430$	22.95	275	8.94	104.2	0.3	8.30
084445$	22.95	274	8.90	103.8	0.4	8.29
084500$	22.95	275	8.95	104.3	0.3	8.30
084515$	22.94	273	8.93	104.0	0.3	8.30
084530$	22.95	273	8.91	103.8	0.3	8.30
084545$	22.95	273	8.84	103.0	0.4	8.29
084600$	22.95	273	8.80	102.8	0.3	8.30
084615$	22.95	273	8.53	99.5	0.3	8.30
084630$	22.94	273	8.48	98.8	0.4	8.29
084645$	22.93	273	8.45	98.5	0.3	8.30
084700$	22.93	273	8.63	100.5	0.3	8.30
084715$	22.92	273	8.52	99.3	0.4	8.29
084730$	22.93	273	8.57	99.8	0.4	8.29
084745$	22.92	273	8.54	99.5	0.4	8.29
084800$	22.93	273	8.68	101.1	0.4	8.30
Bloody Run Creek						
Stn 11-02-0017						
Date (MMDDYY) 080300						
085600$	22.93	274	8.90	103.7	0.5	8.26
085615$	22.94	274	8.85	103.1	0.5	8.26
085630$	22.94	274	8.79	102.4	0.5	8.27
085645$	22.94	274	8.76	102.1	0.5	8.26
085700$	22.94	274	8.80	102.6	0.5	8.26
085715$	22.92	274	8.72	101.6	0.5	8.26
085730$	22.94	274	8.99	104.8	0.5	8.27
085745$	22.95	273	8.99	104.8	0.5	8.27
085800$	22.95	273	8.62	100.5	0.5	8.27
085815$	22.94	273	8.73	101.7	0.5	8.27
085830$	22.95	273	8.82	102.8	0.5	8.26
085845$	22.95	273	8.70	101.4	0.5	8.26
085900$	22.95	273	8.63	100.8	0.5	8.26
085915$	22.95	273	8.49	98.9	0.5	8.26
085930$	22.95	273	8.62	100.5	0.5	8.26
085945$	22.94	273	8.76	102.1	0.6	8.26
090000$	22.95	273	8.80	102.6	0.6	8.26
090015$	22.95	273	8.64	100.7	0.6	8.26
090030$	22.94	273	8.61	100.4	0.5	8.26

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Bloody Run Creek (downstream)						
Stn 11-02-0025						
Date (MMDDYY) 080300						
090945$	22 92	274	8 84	103 1	0 6	8 27
091000$	22 92	274	8 81	102 7	0 7	8 27
091015$	22 92	274	9 09	105 9	0 7	8 27
091030$	22 91	274	9 06	105 5	0 7	8 27
091045$	22 92	274	9 00	104 8	0 6	8 27
091100$	22 92	274	8 98	104 4	0 7	8 27
103945$	22 97	287	7 69	89 7	0 1	8 04
104000$	22 99	287	7 77	90 6	0 1	8 02
104015$	22 98	287	7 73	90 2	0 1	8 02
104030$	23 01	288	7 70	89 9	0 1	8 01
104045$	23 01	289	7.61	88 8	0 1	7 99
104100$	22 99	287	7 67	89 4	0 1	7 99
104115$	22 97	285	7 69	89 7	0 1	8 00
104130$	22 98	288	7 68	89 6	0 1	8 00
104145$	22 99	287	7 66	89 3	0 1	8 00
104200$	22 99	287	7 76	90 5	0 1	8 00
104215$	22 98	287	7 75	90 5	0 1	8 00
104230$	22 97	286	7 76	90 6	0 1	8 00
104245$	22 97	287	7 76	90 6	0 1	8 00
104300$	22 98	288	7 74	90 2	0 1	8 00
104315$	22 98	287	7 75	90 3	0 1	8 00
104330$	22 98	287	7 75	90 4	0 1	8 00
104345$	22 98	287	7 75	90 3	0 1	8 00
104400$	22 97	287	7 63	89 0	0 1	8 00
104415$	22 98	288	7 62	88 9	0 1	8 00
Lyon's Creek						
Stn 05-15-0020						
Date (MMDDYY) 080300						
104800$	22 97	288	7 74	90 3	0 1	7 99
104815$	22 98	287	7 74	90 2	0 1	8 00
104830$	22 97	287	7 76	90 6	0 1	7 99
104845$	22 98	288	7 79	90 9	0 1	7 99
104900$	22 97	288	7 66	89 4	0 1	7 99
104915$	22 97	287	7 71	90 0	0 1	7 99
104930$	22 96	287	7 84	91 4	0 1	7 99
104945$	22 98	288	7 67	89 4	0 1	7 99
105000$	22 98	288	7 61	88 7	0 1	7 99
105015$	22 97	287	7 56	88 2	0 1	7 99
105030$	22 96	287	7 62	88 8	0 1	7 99
105045$	22 98	288	7 57	88 4	0 1	7 99
105100$	22 96	287	7 58	88 4	0 1	7 99
105115$	22 95	287	7 57	88 3	0 1	7 99
105130$	22 97	288	7 53	87 8	0 1	7 99
105145$	22 96	287	7 54	87 9	0 1	7 99
105200$	22 97	288	7 51	87 6	0 1	7 98
105215$	22 96	288	7 52	87 7	0 1	7 98
105230$	22 96	287	7 50	87 5	0 1	7 98
105245$	22 97	288	7 50	87 5	0 1	7 98
Fort Erie						
Stn 05-02-0205						
Date (MMDDYY) 080300						
120445$	22 52	270	8 02	92 7	0 1	8 23
120500$	22 50	269	8 00	92 4	0 1	8 21
120515$	22 48	268	7 99	92 3	0 1	8 20
120530$	22 48	268	7 93	91 6	0 2	8 20
120545$	22 49	268	7 98	92 2	0 2	8 21
120600$	22 49	268	8 00	92 5	0 1	8 21
120615$	22 51	269	7 95	91 8	0 2	8 21
120630$	22 50	269	7 99	92 3	0 1	8 22
120645$	22 51	269	7 94	91 8	0 2	8 21
120700$	22 48	268	7 96	92 0	0 2	8 20
120715$	22 47	268	7 95	91 8	0 2	8 20
120730$	22 49	269	7 97	92 1	0 2	8 21
120745$	22 49	269	7 96	92 0	0 2	8 20
120800$	22 50	269	7 94	91 8	0 2	8 22
120815$	22 50	269	7 99	92 4	0 2	8 22
120830$	22 50	269	7 98	92 3	0 2	8 22
Boyer's Creek						
Stn 05-15-0005						
Date (MMDDYY) 080300						
124415$	21 18	413	4 34	48 9	0 1	7 25
124430$	21 18	413	4 21	47 5	0 1	7 25
124445$	21 21	413	4 19	47 2	0 1	7 24
124500$	21 22	412	4 22	47 6	0 1	7 23
124515$	21 22	412	4 30	48 5	0 1	7 22
124530$	21 23	411	4 24	47 8	0 1	7 22
124545$	21 24	412	4 27	48 2	0 1	7 21
124600$	21 23	412	4 27	48 2	0 1	7 21
124615$	21 23	412	4 31	48 7	0 1	7 21
124630$	21 23	413	4 29	48 4	0 1	7 21
124645$	21 23	412	4 32	48 7	0 1	7 21
124700$	21 24	412	4 22	47 6	0 1	7 20
124715$	21 24	411	4 40	49 6	0 1	7 20
124730$	21 25	411	4 40	49 6	0 1	7 19
124745$	21 24	411	4 36	49 3	0 1	7 19
124800$	21 24	411	4 32	48 8	0 1	7 19
124815$	21 23	411	4 23	47 7	0 1	7 19

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Chippawa Channel						
Stn 05-02-0051						
132045$	22 86	275	7 45	86 7	0 2	6 22
132100$	22 84	275	7 51	87 4	0 2	6 20
132115$	22 85	275	7 47	86 9	0 2	6 19
132130$	22 84	275	7 57	88 1	0 2	6 20
132145$	22 86	275	7 49	87 2	0 2	8 23
132200$	22 85	275	7 49	87 1	0 2	8 21
132215$	22 86	275	7 64	88 9	0 2	8 23
132230$	22 88	275	7 73	90 0	0 2	6 24
132245$	22 88	275	7 62	91 1	0.2	6 25
132300$	22 90	274	7 94	92 4	0 2	6 26
132315$	22 87	275	7 90	92 0	0 2	8 24
132330$	22 87	275	7 79	90 7	0 2	6 23
132345$	22 88	275	7 89	91 6	0 2	8 25
132400$	22 87	275	7 77	90 4	0 2	6 22
132415$	22 86	275	7 69	89 5	0 2	8 22
132430$	22 87	275	7 69	89 5	0 2	6 21
132445$	22 88	275	7 67	89 3	0 2	8 22
Storm sewer A						
Stn 05-02-0046						
Date (MMDDYY) 080400						
084500$	22 71	308	6 68	77 5	0 2	7 86
084515$	22 71	307	6 64	79 3	0 2	7 67
084530$	22 73	308	6 97	81 0	0 2	7 85
084545$	22 72	308	6 61	79 0	0 2	7 86
084700$	22 74	307	7 15	83 0	0 3	7 86
084715$	22 75	307	6 94	80 8	0 3	7 86
084730$	22 74	307	8 85	79 5	0 3	7 86
084745$	22 74	307	8 86	79 7	0 3	7 86
084800$	22 75	307	6 84	79 5	0 2	7 86
084815$	22 75	307	6 78	78 7	0 2	7 86
084830$	22 75	307	6 84	79 5	0 2	7 85
084845$	22 74	307	8 80	78 0	0 2	7 86
084900$	22 75	307	6 73	78 2	0 2	7 86
084915$	22 74	307	6 60	76 7	0 2	7 86
084930$	22 75	307	8 57	76 3	0 3	7 86
084945$	22 75	307	8 87	77 4	0 2	7 86
085000$	22 75	307	6 66	77 3	0 2	7 85
085015$	22 75	307	6 64	77 1	0 2	7 86
085030$	22 75	308	6 66	77 4	0 2	7 85
085045$	22 75	308	6 60	76 6	0 2	7 85
085100$	22 74	307	6 64	77 1	0 2	7 85
085115$	22 75	308	6 61	76 6	0 2	7 86
Sewer B						
Stn 05-02-094						
Date (MMDDYY) 080400						
085945$	22 73	305	5 37	62 4	0 4	7 79
090000$	22 71	306	5 81	67 5	0 4	7 78
090015$	22 74	306	5 70	66 1	0 4	7 79
090030$	22 73	306	5 58	64 6	0 4	7 80
090045$	22 73	306	5 57	84 7	0 4	7 78
090100$	22 73	306	5 34	62 0	0 4	7 77
090115$	22 73	306	5 47	63 5	0 4	7 77
090130$	22 74	306	5 38	62 5	0 4	7 76
090145$	22 72	306	5 45	63 3	0 4	7 78
090200$	22 66	306	5 74	66 8	0 4	7 76
090215$	22 67	306	5 40	62 6	0 4	7 78
090230$	22 68	306	5 17	59 9	0 4	7 77
090245$	22 66	306	5 25	60 9	0 4	7 77
Between Sewer B and C						
Stn 05-02-045						
090300$	22 64	306	5 21	60 4	0 4	7 77
090315$	22 69	306	5 39	62 6	0 4	7 76
090330$	22 70	306	5 54	64 3	0 4	7 74
090345$	22 70	306	5 31	81 8	0 4	7 73
090400$	22 71	306	5 42	62 9	0 4	7 73
090415$	22 72	306	5 28	61 3	0 4	7 74
090430$	22 72	306	5 43	63 0	0 4	7 75
090445$	22 69	306	5 50	63 9	0 4	7 75
090500$	22 72	306	5 38	62 4	0 4	7 74
090515$	22 72	306	5 48	63 8	0 4	7 75
090530$	22 72	306	5 48	63 7	0 4	7 78
090545$	22 72	306	5 28	61 3	0 4	7 76

Time HHMMSS	Temp deg C	SpCond uS/cm	DO mg/l	DO % Sat	Depth meters	pH units
Sewer C						
Stn 05-02-0044						
Date (MMDDYY) 080400						
091300$	22 76	306	6 67	77 5	0 2	7 86
091315$	22 76	306	6 66	77 3	0 2	7 66
091330$	22 78	306	6 64	77 1	0 2	7 86
091345$	22 77	306	6 60	76 7	0 2	7 86
091400$	22 75	305	6 60	76 7	0 2	7 86
091415$	22 77	306	6 45	74 9	0 2	7 86
091430$	22 76	305	6 39	74 2	0 2	7 65
091445$	22 77	306	6 43	74 7	0 2	7 84
091500$	22 76	305	6 29	73 1	0 2	7 64
091745$	22 64	305	6 25	72 4	0 4	7 76
091800$	22 62	305	6 37	73 6	0 0	7 70
091615$	22 67	306	6 21	72 0	0 4	7 70
091630$	22 65	306	5 76	67 0	0 4	7 68
091645$	22 66	305	5 56	64 4	0 4	7 67
091900$	22 65	305	5 48	63 3	0 4	7 68
091915$	22 67	305	5 75	66 7	0 4	7 71
091930$	22 69	305	5 79	67 1	0 4	7 75
091945$	22 67	305	5 49	63 6	0 4	7 76
092000$	22 66	305	5 35	62 1	0 4	7 78
092015$	22 69	305	5 12	59 4	0 4	7 76
092030$	22 65	305	5 01	58 1	0 4	7 77
092045$	22 65	305	5 03	58 3	0 4	7 77
092100$	22 65	305	5 10	59 1	0 4	7 77
Downstream Sewer C						
Stn 05-02-0043						
Date (MMDDYY) 080400						
092700$	22 72	305	5 70	66 2	0 4	7 76
092715$	22 71	305	5 60	65 0	0 4	7 79
092730$	22 70	305	5 50	63 6	0 4	7 79
092745$	22 70	306	5 30	61 4	0 4	7 79
092800$	22 69	305	5 33	61 9	0 4	7 79
092815$	22.69	305	5 29	81 3	0 4	7 79
092830$	22 70	305	5 26	61.0	0 4	7 79
092845$	22 70	305	5 35	62 1	0 4	7 79
092900$	22.69	305	5 42	62 9	0 4	7 76
092915$	22.67	305	5 53	64 1	0 4	7 77
092930$	22.64	305	5 62	65 2	0 4	7 74
092945$	22.63	306	5 35	62 0	0 4	7 72
093400$	22 76	306	6 39	74 2	0 1	7 82
093415$	22 74	306	6 42	74 6	0 1	7 80
093430$	22 76	306	6 54	76 0	0 1	7 62
093445$	22.75	306	6 43	74 6	0 1	7 82
093500$	22 74	305	6 44	74 6	0 1	7 61
093515$	22 73	305	6 40	74 3	0 1	7 60
093530$	22 77	305	6 59	76 6	0 1	7 61
093545$	22 77	305	6 53	75 9	0 1	7 61
093600$	22 75	306	6 46	75 0	0 1	7 80
093615$	22.75	306	6 50	75 5	0 1	7 80
093630$	22 75	306	6 35	73 6	0 1	7 81
093645$	22 75	306	6 48	75 3	0 1	7 80
Sewer 003						
Stn 05-02-0042						
Date (MMDDYY) 080400						
094900$	23 37	376	6 20	72 9	0 2	7 65
094915$	23 33	375	6 19	72 7	0 2	7 64
094930$	23 37	376	6 17	72 5	0 2	7 65
094945$	23 36	376	6 10	71 7	0 2	7 65
095000$	23 33	376	6 20	72 6	0 2	7 64
095015$	23 41	377	6 58	77 2	0 2	7 64
095030$	23 38	377	6 64	78 0	0 2	7 64
095045$	23 44	380	6 70	78 9	0 2	7 64
095100$	23 39	378	6 60	77 8	0 2	7 64
095115$	23 40	376	6 37	74 9	0 2	7 64
095130$	23 40	376	6 23	73 3	0 2	7 64
095145$	23 43	377	6 13	72 2	0 2	7 64
095200$	23 46	383	6 33	74 5	0 2	7 62
095215$	23 43	380	6 60	77 7	0 2	7 63
Storm sewer S&N						
Stn 05-02-0040						
Date (MMDDYY) 080400						
100000$	23 09	339	6 77	79 2	0 4	7 73
100015$	23 05	334	6 76	79 3	0 4	7 75
100030$	23 08	338	6 77	79 2	0 4	7 74
100045$	23 06	337	6 77	79 2	0 4	7 74
100100$	23 09	337	6 64	79 9	0 4	7 74
100115$	23 09	338	6 76	79 0	0 4	7 74
100130$	23 10	340	6 77	79 2	0 4	7 74
100145$	23 10	340	6 88	80 5	0 4	7 73
100200$	23 10	339	6 80	79 5	0 4	7 74
100215$	23 10	340	6 84	80 0	0 4	7 74
100230$	23 10	339	6 75	78 9	0 4	7 74
100245$	23 11	341	6 80	79 5	0 4	7 74
100300$	23 11	340	8 81	79 7	0 4	7 74
100315$	23 11	340	6 61	79 7	0 4	7 74

Appendix D1: HydroLab data for Two Mile Creek while caged mussels were retrieved, 2000

Station	Date		Temp øC	SpCond æS/cm	DO mg/l	DO% Sat	pH Units
Two Mile Ck	18-Jul	mean	19.77	1091.7	3.5	38.6	7.5
		SD	0.036	3.4	0.1	0.6	0.0
	25-Jul	mean	20.07	1088.1	5.7	62.9	7.4
		SD	0.123	3.7	0.1	1.0	0.0
	01-Aug	mean	21.43	639.5	1.4	16.1	7.0
		SD	0.067	6.6	0.1	1.2	0.0
	12-Sep	mean	22.27	930.4	3.5	40.7	7.5
		SD	0.013	2.0	0.2	2.5	0.1
	02-Oct	mean	18.65	695.4	5.4	58.2	7.5
		SD	0.197	18.0	0.2	2.5	0.0
	24-Oct	mean	13.4	670.0	6.8	64.8	7.4
		SD	0.0	6.5	0.3	2.7	0.0